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HUMANKIND'S GREATEST TOOL

plus

The Future of Off-Roading Is Electric p.40

Can You Solve This Confounding Brain Teaser? p.20

Pop Mech Pro Challenge — Build Something Useful With LEGO p.26

Best Smart Locks, Portable Air Conditioners, Handheld Devices, and More p.68

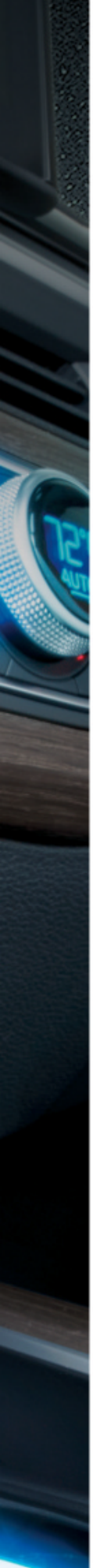
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// STANDARDS //

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// FEATURES //



The History of Maps

No clear origin. No known inventor. But are maps the most underappreciated "device" of all time? **p.30**



The Future of Off-Road Is Electric

As soon as 2021, the best adventure vehicles will come from Rivian, Bollinger, and Tesla. **p.40**



The Race to Make Cell-Grown Meats Mainstream

Would you eat a chicken nugget that came from a petri dish? **p.44**



When Grizzlies Invade Your Neighborhood

Why an apex predator returned to Shelby, Montana—a place now overrun with humans. **p.52**

// ON THE COVER // 1904 USGS TOPOGRAPHIC MAP OF THE MOUNT DESERT QUADRANGLE, MAINE. DIGITALLY RENDERED ELEVATION BY SCOTT REINHARD.

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1 My Pop Life

// EXPERT HACKS, GEAR RECS & LIFE-TESTED WISDOM FROM OUR STAFF //



DAISY HERNANDEZ

News Editor

Waiting for my phone to stop ringing so I can go back to snapping pics of my pup.

CURRENT PASSION PROJECT

A home reno! We closed on a home at the end of January and have been completely redoing the entire property.

The Best Money I Ever Spent

Definitely the money I used to take a trip to Iceland in 2017. Being there was surreal—like visiting an entirely new world.

My Favorite POP Story So Far

"Burning Out: What Really Happens in a Crematorium"—I've always been morbidly curious about undertaking.



THIS IS SONNY

She's a three-month-old Australian cattle dog/Shiba mix we recently rescued from our local animal shelter. She spends half the day sleeping to recover from being insanely rambunctious the other half of the day.

PRODUCTS I'M USING RIGHT NOW



1

Sony MDR-XB950BT Headphones

Even after sweaty gym sessions and long hours in the office, the sound quality of these remains perfect.



2

DW Home Tobacco Flower Candle

I buy these candles three or four at a time—they smell divine and make any space feel welcoming and cozy.



3

Cuisinart Espresso Machine

This elevates my coffee game. Whether I feel like an espresso or a cappuccino, I can make one exactly how I like it.



4

Ludwig Drum Kit

My grandpa taught me how to play on his kit and eventually bought me my first drum set a few years ago.

COOLEST THING ON MY DESK

A pencil holder made from old ball bearings that have been welded together.



Alexander George
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1 My Pop Life

// EXPERT HACKS, GEAR RECS & LIFE-TESTED WISDOM FROM OUR STAFF //



KORY KENNEDY

Digital Designer

But the creator is the man who disagrees.

Parenting Hack

I came up with "Activity Bingo" to get my sons away from their screens. It's a bingo board with 25 physical activities, from 15 mountain climbers to 30 "Rocky" situps. Once it's filled, they choose a non-digital prize.

The Best Thing I Have on My Desk

A baggie of "Blue Sky" from the set of *Breaking Bad*. (Although I question its purity—it's clearly losing its bluish color over time.)



PRODUCTS I'M USING RIGHT NOW



1

Rabbit Lever Corkscrew

I love the ritual of lifting it out of the drawer, positioning it atop a bottle, and smoothly extracting the cork.



2

Vans Comfy Cush Sneakers

So much softer and more cushiony than a lot of other models. Out of all my sneakers, my new favorites!



3

LifeProof Vinyl Plank Flooring

Finally pulled up the carpet and replaced with this flooring. It's designed to hide any repeating patterns.



4

JBL Bar Studio

Hook up an optical cord, plug it in, and pump up the volume!

My Favorite POP Story So Far

"How *Star Wars* Filmmakers Built the Millennium Falcon." As a *Star Wars*–obsessed fan since day one, I got chills when my favorite "piece of junk" was reintroduced in *The Force Awakens*. It was inspiring taking a deep dive into its inception (not to mention geeking out while designing the story).

The Best Money I Ever Spent

I spent the majority of my childhood in arcades, so I saved up my quarters and got my own refurbished Donkey Kong Jr. arcade game. It's upgraded with more than 30 classic games, such as Mr. Do!, BurgerTime, Zaxxon, and the entire PAC-MAN family.



SAY "MEOW" AGAIN!

Meet Jules and Vincent. As entertaining as their *Pulp Fiction* namesakes, with similar criminal tendencies.

Jack Essig
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Should Your Car Have Solar Panels?



YOU CAN GET THEM ON THE NEW Hyundai Sonata Hybrid Limited ($35,300), which I tested one for a week, under existentially strange but mechanically ideal conditions. Except for a 10-mile drive to the grocery store and back, the car sat in the driveway, its 205-watt system earning free, clean power, I thought.

Hyundai estimates that a day with at least six hours of good sun will gain two miles of range. But those figures are for a car in Los Angeles—where a lack of driving has cleared pollution. The cloud-covered northeast, where I was, wasn't as efficient. During my week with it, if the panels were working, I couldn't tell. Maybe they were gathering power to run the air conditioning and radio. But the car's range calculator (552 miles) was the same at dawn as it was at dinnertime. I thought about what Tesla's CEO said a few years ago: "The least efficient place to put solar is on the car."

But I liked having them. It became a challenge to wait as long as possible before driving. You think, every trip I make by bicycle means more time for the panels to work, even if it's just a trickle-charge that keeps the batteries healthy. It was like letting a plant grow. Besides, look. In Spring 2020, suddenly, everything that felt necessary—next-day shipping, fully stocked grocery stores—became a luxury. We had to realize that everything has a cost. The panels made me confront how much energy is required to buy fruit. I thought about whether I'd earned those miles, and whether they were necessary. You want to hold out, and see how few resources you can use.

It reminded me of the first electric vehicle I ever drove, a Zero DS motorcycle. The first day, I ignored the range warnings and stranded myself at the side of a highway, like an idiot. After I had pushed the bike to a gas station and asked if I could use an outlet, I waited an hour until I had enough power to ride home. I should have thought, EVs just can't meet our needs! But I came to like the idea of carefully planning my day around range and infrastructure, of only traveling the necessary minimum. I thought then, as I do now, that having to be deliberate makes us behave better and waste less.

It probably helped that these months have forced me, and everyone, to be more self-sufficient. It took a catastrophe for me to learn embarrassingly simple things, like baking and bicycle maintenance. A car with solar panels pushed me in the same direction, away from waste. Of course, real restraint would mean quitting driving, and only riding that bicycle. Someday, maybe. PM

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3

Drinks

// BY ADRIENNE DONICA //



Before There Was White Claw, There Were Highballs

IN THE BLAZING SUMMER HEAT, NOTHING feels quite so refreshing as a sparkling cocktail. Bartenders and the spirits industry have quenched our collective thirst with one fizzy drink after another, be it a scotch and soda, Aperol spritz, or most recently a White Claw. Canned hard seltzer—a low-ABV concoction of seltzer water, alcohol made from fermented sugars, and fruit flavors—became last summer's unofficial drink, with sales skyrocketing by more than 286 percent, to $2.73 billion, from 2018 to 2019. Trendy? Definitely. But new to the drinking scene? Not exactly.

LAKOTA GAMBILL

"This is a drink that's based off a long history of a similar drink," says Derek Brown, who owns the award-winning bar Columbia Room in Washington, D.C. "This is not very new that people are consuming essentially what amounts to a highball." A highball, typically two parts whiskey to four parts carbonated water, is a classic cocktail that's been around for more than 100 years. And like all classic cocktails, it's been remade time and again with different liquors and carbonated mixers used in roughly the same ratio as the original recipe. Jack and Coke, gin and tonic, vodka soda, and the Americano are just some of the ways that original recipe has been transformed into new drinks. Swap whatever spirit and mixer into the formula you like, and you'll still get a relatively low-ABV, highly refreshing cocktail that's simple to make and easy to drink. But the real secret to the highball's staying power lies in the bubbles.

Producing soda water is as straightforward as infusing carbon dioxide into H_2O. "It's a really simple product, but it seems to have captured the imagination of the world for a couple hundred years," bartender and chemist Darcy O'Neil says. One reason is that bubbles make a cocktail more fragrant, a process you can see in action as small droplets of liquid come flying out of a glass. This primes our palate, helping us parse out flavors, even before we've taken a sip and felt the fizzy sensation. "Carbonation is a unique feeling," O'Neil says. "It's actually a chemical reaction on your tongue." Scientists first assumed the fizziness was the physical sensation of CO_2 expanding on our taste buds. Later, they discovered that the carbonic acid, produced when carbon dioxide combines with water, registers on our pain receptors as a mild irritant. But it's the kind of irritation that most people enjoy, not unlike spicy foods.

As simple as the carbonation process is, the world of fizzy water isn't uniform, and unless you're making highballs with homemade sparkling water, you're going to face some choices at the liquor store. Club soda was once a trademarked name for seltzer, which has a very neutral, clean taste. (Today, the terms and the beverages can be used interchangeably.) The high pressure used in the carbonation process results in large bubbles. Mineral water is similar but has a distinct saltiness introduced by the mineral content and typically has finer bubbles (more akin to champagne's) because of the lower pressure used in the bottling process. Brown likes to use it in a gin rickey (2 oz. gin, ¾ oz. lime juice, and mineral water). Tonic is in another category altogether and best left for your G&Ts; the bitter-tasting quinine is usually balanced by a fair amount of sugar, and the more pronounced flavor can alter your cocktail's taste. At the end of the day, Brown says, "Bubbly water is bubbly water." Yes, there are differences, but your highball will taste just as refreshing whether you use seltzer, club soda, or mineral water. PM

THREE HIGHBALLS PERFECT FOR SUMMER SIPPIN'



FROM LEFT: GETTY IMAGES; LAKOTA GAMBILL; COURTESY DARCY O'NEIL

THE RED CLAW

1 oz. Campari
6 oz. lime seltzer
Dash of Peychaud's Bitters
Orange slice (optional)

Fill a glass with ice. Pour in seltzer, followed by Campari and bitters. Stir briefly. Garnish with orange slice.

HORSE'S NECK

1½ oz. whiskey (bourbon or rye)
4 oz. ginger beer
Peel from one lemon

Place lemon peel into a Collins glass and fill with ice. Add whiskey, top with ginger beer, and stir briefly. For a twist, add a dash of aromatic bitters.

ANGOSTURA PHOSPHATE

½ tsp. acid phosphate
1 tsp. Angostura bitters
1 oz. lemon syrup
Soda water

Combine the first three ingredients in a Collins glass. Add soda water and ice (if desired); stir briefly. *Note: Acid phosphate adds a dry, tart flavor to drinks. You can buy it online.*

To make the lemon syrup: Stir ¾ cup of sugar into the juice from four lemons. In another bowl, mix 1 tsp. of gum arabic and ¼ tsp. of lemon oil. Combine the mixtures, heating if necessary, to incorporate. Refrigerate extra syrup.

4

Machines

//BY ALEX HOLLINGS //



The B-52 Is America's Longest-Serving Plane—and the Most Badass

LIKE MANY OF AMERICA'S legendary aircraft, the B-52 was built to offset the Soviet threat that characterized the Cold War. The U.S. needed a bomber to reach far-flung Soviet targets, defeat their air defenses, and carry a massive atomic payload.

Boeing's initial 1948 designs included swept wings and six massive turboprop engines—a nod to the Soviets' long-range bomber, the Tupolev Tu-95 Bear. But when one brash Army officer fielded Boeing's proposal and told the aeronautical designers to ditch the props, they came back with an all-new, eight-engine jet bomber. One Boeing ▸

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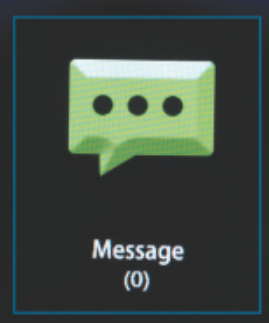
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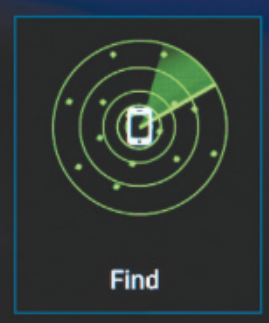
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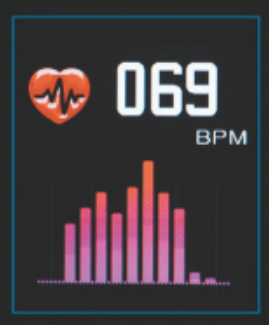
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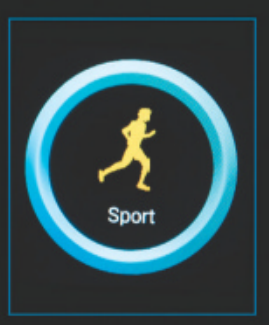
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4 Machines

▸ historian would later call it "the perfect form of the subsonic jet."

The first B-52 Stratofortress hit the skies on April 15, 1952, three years after the Soviet Union developed its first atomic weapon. It would take three more years for the nearly 160-foot long B-52 to enter service, and once it did, the U.S. was eager to demonstrate its newfound bombing capabilities.

It was the addition of looped-hose in-flight refueling technology that made the bomber a truly global threat. In January 1957, three B-52s conducted a simulated bombing run over the Malay Peninsula before landing safely a record two days later at March Air Force Base in California—less than half the time it took for Boeing's B-50 Superfortress to fly non-stop around the world in 1949.

The B-52's massive airframe allowed for weapons and electronics that hadn't even been invented yet. For a time, the B-52 served as a low-altitude penetration bomber, coming in for runs at just 300 feet above the ground to avoid rapidly developing air defense systems. Eventually, the plane's subsonic top speed made it too slow for highly contested airspace, but the advent of nuclear-tipped cruise missiles meant the B-52 could retain its spot in the airborne portion of America's nuclear triad.

Throughout the 1960s, B-52s carrying nuclear weapons under the banner of America's Strategic Air Command were airborne 24 hours a day, circling just outside of Soviet airspace to provide an immediate nuclear response to an attack. Today, the B-52 is the only jet in active service to run eight Pratt & Whitney turbofan jet engines, which allow it to carry 70,000 pounds of ordnance 8,800 miles without refueling. It's also found use outside the nuclear realm thanks to its payload and loitering capabilities, and its deep weapons magazine and upgraded flight systems give it a place in precision bombing and close air support missions.

B-52s have participated in combat operations throughout the Global War on Terrorism, including bombing runs over Afghanistan during Operation Enduring Freedom. Recent upgrades to the B-52's internal weapons bays now allow it to carry advanced Joint Direct Attack Munitions and Joint Air-to-Surface Standoff Missiles, alongside a bevy of other munition options. These upgrades have produced about a 66 percent increase in the B-52's payload capabilities, helping to ensure the aircraft remains a workhorse for decades to come.

Indeed, the B-52 should fly long after the last B-2 Spirit and B-1B Lancer—both to be replaced by the B-21 Raider, America's next long-range, heavy payload bomber—are gone. Thanks to continued upgrades, the Air Force now expects its fleet of 76 B-52Hs to remain in service until at least 2050.

To sustain combat operations, the B-52 will need a slew of new technologies. The Air Force has already set about installing new cockpit displays, active electronically scanned array radar, and secure data links that make it a bomber and a valuable aerial reconnaissance asset. The B-52 should also carry some of America's first operational hypersonic missiles, which can travel sustained speeds in excess of Mach 5.

The B-52 "Stratosaurus," as some call it, may lack modern stealth capabilities, but its reliability, payload capabilities, and flexibility have ensured its continued service. While platforms like the B-21 and F-35 Joint Strike Fighter may clear the path, once air defenses are down, the mighty B-52 will still bring the heat. PM

Going the Distance

How has the B-52 stood the test of time while other military aircraft haven't? Because it was engineered to keep aerodynamic and payload forces in balance during missions, minimizing stresses that weaken other planes over time. Active B-52s aren't patchwork quilts of structural components pilfered from retired airframes—they're almost entirely the real thing, down to the flight controls, control surfaces, and cable linkages. The Air Force has also (mostly) held off on modifying the B-52's core hardware. While it seemingly makes sense to upgrade the eight low-bypass engines with four modern, high-bypass engines, that requires a costly redesign of the entire wing, since the new engines' weight and placement would have been dramatically different from the original Pratt & Whitney J57 turbojets, which hung in pods of two each. Now that the Air Force has accepted the bomber's heroic longevity, it's weighing options for a re-engining program, since modern, more reliable engines include a variety of sensors that can monitor their health. With that upgrade and the arrival of modern inspection technologies that will help maintenance personnel assess possible metal fatigue in the structural components, there's no reason the plane can't continue serving the U.S. military for decades to come.—*Eric Adams*

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// BY EZRA DYER //

How to Use Your 4WD System



WITH CROSSOVERS AND SUVS supplanting sedans as the default choice for everyday transportation, it's common for any given vehicle to sport four- or all-wheel drive (4WD and AWD). Most new models have fully automatic AWD systems that will detect wheel slip and automatically divert power to the wheels with traction, no driver involvement required. But in most trucks and some SUVs with 4WD, there will be at least two drive configurations you can choose from to maximize your vehicle's capability in a given situation. If you drive an SUV with an off-road bent, like a Toyota Land Cruiser, you have even more choices—high range, low range, locked or unlocked center differential. It gets complicated quickly.

But let's begin with the biggest topic of confusion: 4WD versus AWD. With AWD, there's a center differential that allows the front and rear tires to rotate at different speeds. For commuting to work in three inches of sleet, AWD will keep you safe. Driving on something trickier than a snowy path? You'll want 4WD, to eliminate slip in the system front-to-rear. If you're ready to find out what your 4WD system can do, start here .



If you have a 4WD vehicle with knobs or buttons that let you choose between two- and four-wheel drive, and you're on a normal road, use 4WD Auto. Both 2WD and 4WD Auto are fine for dry pavement. The only advantage of running in 2WD would be some marginal fuel-economy benefit, or saving wear on the front-drive system. But if it starts raining, already being in 4WD Auto means that extra traction will be there to save you, before you remember that you might need it.



BEFORE YOU GO OFF-ROAD

If you're in mud, sand, or snow, even if you have four-wheel drive, electronic stability control (ESC) might actually get you stuck. That's because the system is designed to cut power to any tires that are spinning—which, in this case, will be all of them—so you grind to a halt. But off-road, wheel spin is good, because it helps preserve forward momentum. To turn off ESC, find the button with squiggly lines, and hold it down for at least five seconds, until you get visual confirmation that the whole thing is off. Some cars, like Volvos, might not have a dedicated button, but it's in there somewhere—even if it's buried five menus deep in the touch screen.

COURTESY FORD (TRUCK); COLIN MCSHERRY (PANEL)

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5 Cars & Trucks



4WD High locks the front and rear axles together, which is useful in only a few situations. For example, somewhere low-traction, but high-speed—probably off-road, like a desert wash. Here, 4WD High tends to feel more stable, since the truck won't want to turn. But most of the time, if you have both, you're better off in 4WD Auto, letting the system send power forward or back as needed. A friend used to have a late-'70s Jeep Cherokee with 4WD Auto. The only time he needed to switch it into 4WD High was when he (successfully) drove through a pond.



4WD Low uses gearing to multiply torque to the wheels, useful for slow trails or towing a boat out of the water. But generally, Low is strictly for slow off-roading, which is why it's usually relegated to pickup trucks and SUVs that have serious off-road pretensions. A Toyota 4Runner would have it, but a Highlander wouldn't. One use case for this setting: beach driving, where you want all the torque and traction you can get. Once in 4WD Low, you should also lock the rear differential, usually a switch on the dash with four tires and a little "x" between the rear ones. This locks the rear wheels side-to-side, which can be handy because if one side loses traction, the opposite side keeps spinning, powering you forward. (Just don't use the diff lock on a corner, because the whole point of a differential is to allow your car to make a smooth turn, with the outside tire turning faster than the inside.) There are also a few vehicles with a front differential lock, but if you bought one of those, then you probably know how to use it. PN

JOHN WATSON (JEEP); COURTESY LAND ROVER (DEFENDER)



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// BY ANDREW DANIELS //



We Spent All Day Arguing About This Triangle Brain Teaser. Can You Solve It?

NOTHING HALTS PRODUCTIVITY AMONG coworkers quite like a maddening brain teaser. The latest to ensnare the *Popular Mechanics* editors and readers: How many triangles are in this drawing?

When I posed the problem to our team, responses ranged from 4 triangles all the way to 22. Most people saw 18. One wiseguy counted the triangles in the A's in the question itself, while another seemed to have an existential crisis: "None of these lines are truly straight, just curves—thus you cannot define any of them as a triangle," he said. "There are no triangles in this photo. Life has no meaning."

I could've listened to my colleagues' questionable processes all day, but instead, I reached out to geometry experts to see if we could arrive at a consensus. All of the mathematicians I contacted found the same solution—but not all of them figured it out in the same way.

"I would approach this like one approaches any mathematical problem: reduce it and find structure," says Sylvester Eriksson-Bique, PhD, a postdoctoral fellow with the University of California Los Angeles's math department.

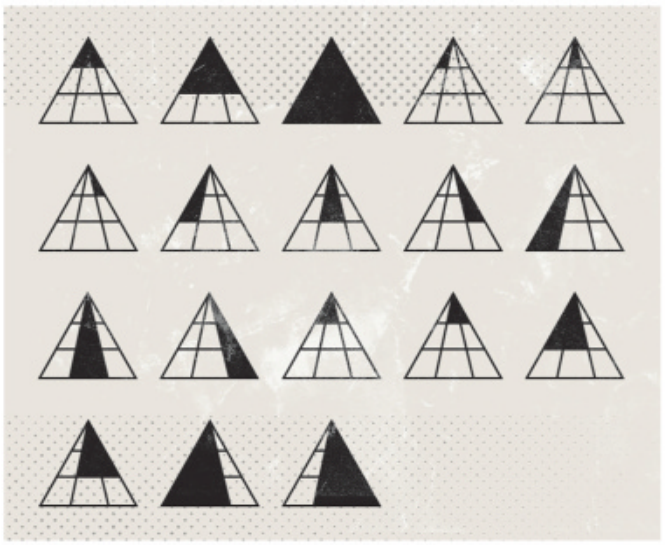
The only way to form triangles in the drawing, Eriksson-Bisque says, is if the top vertex (corner) is part of the triangle. The base of the triangle will then have to be one of the three levels below. "There are three levels, and on each you can choose a base among six different ways. This gives 18, or 3 times 6 triangles."

Look at the triangle again: "It's convenient to generalize to the case where there are 'n' lines passing through the top vertex, and 'p' horizontal lines," says Francis Bonahon, PhD, a professor of mathematics at the University of Southern California.

In our case, n = 4, and p = 3. Any triangle we find in the drawing should have one top vertex and two others on the same horizontal line, so for each horizontal line, the number of triangles is equal to the number of ways we can choose two distinct vertices on that line out of n total points, Bonahon says—or "n choose 2."

That's n(n–1)/2. And since there are p horizontal lines, this gives p*n(n–1)/2 possible triangles. In our case, that's 3*4(4–1)/2 = 18.

Here's a breakdown of how to find each possible triangle:



When we published the problem on *Pop Mech*, readers started sending in their own solutions. Software engineer Slobodan Jaksic came up with a mathematical proof to demystify the triangle teaser. It goes like this:

Two lines meet at the top vertex denoted by "A," and the segment line connecting those two lines is the "base." The new polygon is the fundamental triangle. We can place an arbitrary number of points on the base and connect them to the top vertex A.

Assuming there are "n" vertices on the base, where n is a natural number greater than or equal to 2, we will prove that the new shape—let's call it "pyramid"—contains a number of triangles equal to S(n) = n(n–1) * ½. (See Fig. 1) For n = 2, S(2) = (2 * 1) * ½ = 1. It is correct.

Assuming the formula S(n) holds for n = k, with k greater than or equal to 2, S(k) = k(k–1) * ½. We will prove that S(n), where n = k + 1, holds as well. (See Fig. 2)

In the modified pyramid (See Fig. 3), there are "k" additional new triangles. Therefore,

S(k+1) = S(k) + k = (k(k–1) *½) + k = (k+1) * k * ½.

Modify the pyramid by extending both edge lines, and all lines between them connect to the top vertex A, beyond the base, in the direction opposite of the top vertex. Create new bases by connecting one or more segments parallel to the starting base.

Assuming there are a total of "m" bases in the pyramid, we can prove the formula calculating the number of triangles in the structure is: S(n, m) = n(n–1) * ½ * m.

THE MATHEMATICAL PROOF

When Slobodan Jaksic stumbled upon our brain teaser, the software engineer living in Serbia counted the triangles sideways along the x-axis and vertically along the y-axis before assembling his proof. As such, it breaks down into horizontal and vertical steps.

"I sent my 'conceptual solution' using Mathematical Induction to Francis Bonahon, Professor of Mathematics, University of Southern California," Jaksic says. "He provided...his solution to the problem, with a correct formula, using a different approach." Let that be a reminder that, even among the pros, there are always multiple ways to approach a problem.

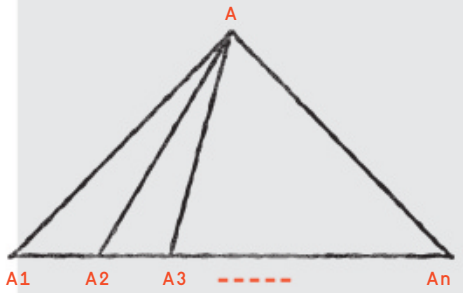


Figure 1

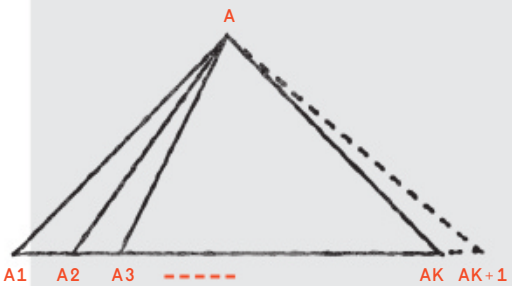


Figure 2

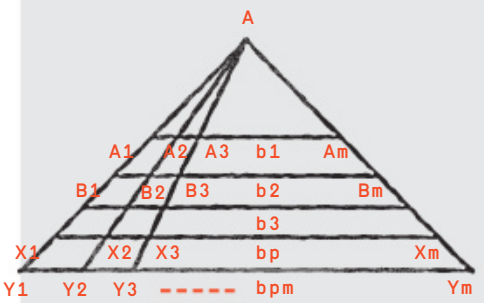


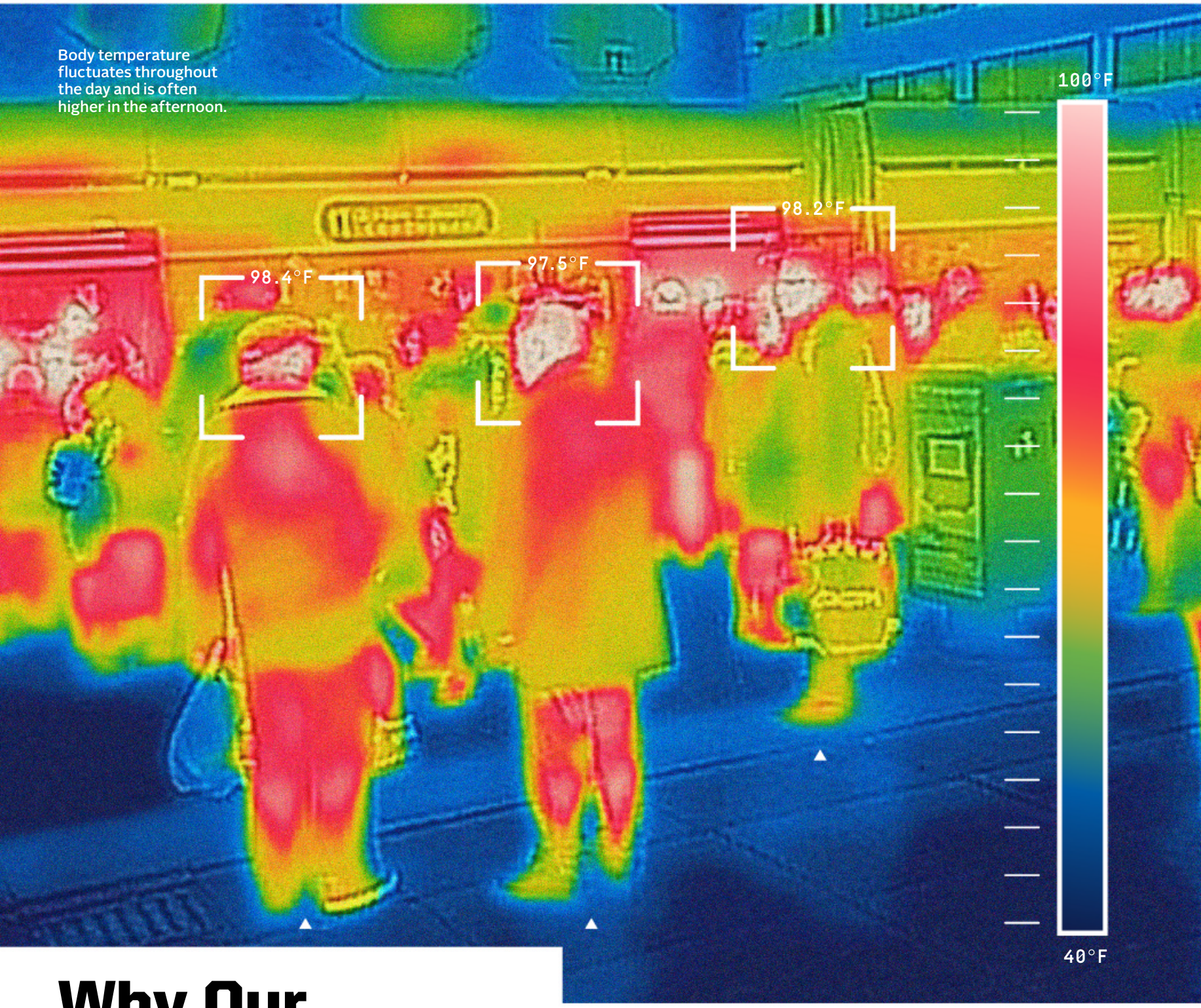
Figure 3

Let's prove that the formula holds for m = p + 1. (See Fig. 3) The number of new triangles can be given as: (n–1) + ... + 2 + 1 = n(n–1) * ½. Consequently, S (n, p+1) = S(n, p) + (n(n–1) * ½) = (n(n–1) * ½) * p + (n(n–1) * ½) = (n(n–1) * ½) (p + 1).

According to the Principles of Mathematical Induction, we just proved the total number of triangles in the pyramid is given through the formula S(n, m) = n (n–1) * ½ * m, where n and m are natural numbers, n is greater than or equal to 2, n is an arbitrary number of vertices, and m is an arbitrary number of bases.

Hat tip to Slobodan. Here I was just trying to annoy my coworkers. PM

// BY CAROLINE DELBERT //



Why Our Bodies Have Gotten Colder With Each Passing Decade

SINCE THE GERMAN PHYSICIAN CARL Reinhold August Wunderlich published his research on human body temperature in 1868, 98.6 degrees Fahrenheit has been the gold standard. Now scientists say that number may be inaccurate. Thanks to improved health outcomes—meaning people are generally healthier and getting better overall medical treatment—the average human body temperature has fallen gradually over time.

"Much as we have changed the Earth ecosystem, we are changing our own ecosystems," says ▸

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▸ Julie Parsonnet, MD, a professor of epidemiology at Stanford University. “We have changed who we are over the modern era.” She and her team analyzed more than 670,000 reported temperatures spanning 157 years of measurement and 197 birth years and found that our temperature has dropped 0.05 degrees Fahrenheit per decade since the mid 1800s. The study was sparked by a review of modern temperature studies where patients uniformly fell below the 98.6-degree Fahrenheit mark—a signal that something was rotten in the state of human body-temperature research.

Parsonnet and her team studied three large sets of data from between 1862 and 2017: temperatures taken during periodic checkups with Civil War veterans between 1862 and 1930; National Health and Nutrition Examination results from the early 1970s; and data from the Stanford Translational Research Integrated Database Environment project taken from 2007 to 2017.

Controlling for changes in how temperatures were taken and advances in thermometry across the large pool of data, they compared body temperature with birth years and found that the average body temperature in men and women has gone down 0.05 degrees Fahrenheit per birth decade.

In their paper published in the journal *eLife,* Parsonnet and her colleagues suggest that a change in inflammation levels over time is the most likely explanation for the decrease in temperature. Inflammation can be caused by bacterial, fungal, or viral infections, surface injuries like scrapes and punctures, or inflammatory conditions like cystitis, bronchitis, and dermatitis. As part of the body’s immune response, inflammation produces cytokines and other proteins that increase metabolism and generate heat.

The development of germ theory (that microorganisms can cause disease) and advances in hygiene have changed how often many of these conditions occur. Today, the length of bacterial infections is shortened by antibiotics. And the symptoms of viruses can often be alleviated with anti-inflammatory drugs like ibuprofen and naproxen, which can bring down your body temperature. Civil War veterans plagued with ailments in the 1800s weren’t as lucky.

Our environment has changed, too. We now have access to healthier foods and are more hygienic. We’ve learned to heat and cool indoor spaces more efficiently, which may also contribute to a lower metabolic rate. These environmental changes beget physiological changes. “We’re taller, fatter, and colder,” Parsonnet says. We also live a lot longer than the average Civil War veteran.

> *"MUCH AS WE HAVE CHANGED THE EARTH ECOSYSTEM, WE ARE CHANGING OUR OWN ECOSYSTEMS," SAYS JULIE PARSONNET, MD, A PROFESSOR OF EPIDEMIOLOGY AT STANFORD UNIVERSITY. "WE HAVE CHANGED WHO WE ARE OVER THE MODERN ERA."*

The world has certainly become a safer, healthier place for humans, but the researchers say it’s hard to single out any one environmental change that’s lowered our temperatures.

Parsonnet says that changing the human body creates ensuant mysteries: what are the outcomes, and how do they change as a consequence of our actions and environment? “They could be good—greater life expectancy, for example. They could be bad—causing obesity and perhaps limiting our ability to deal with new pathogens,” Parsonnet says. “Changing fundamentally who we are may have surprising consequences.”

Parsonnet and her colleagues did not identify a new average body temperature guideline in their study. A recent large review, a 2017 study published in the *British Medical Journal*, for example, found the average body temperature of 35,488 British patients to be around 97.88 degrees Fahrenheit. However, because each person’s own temperature constantly fluctuates and can be influenced by factors like gender, age, and the time of day, many researchers have questioned whether an ideal temperature standard should even exist. PM



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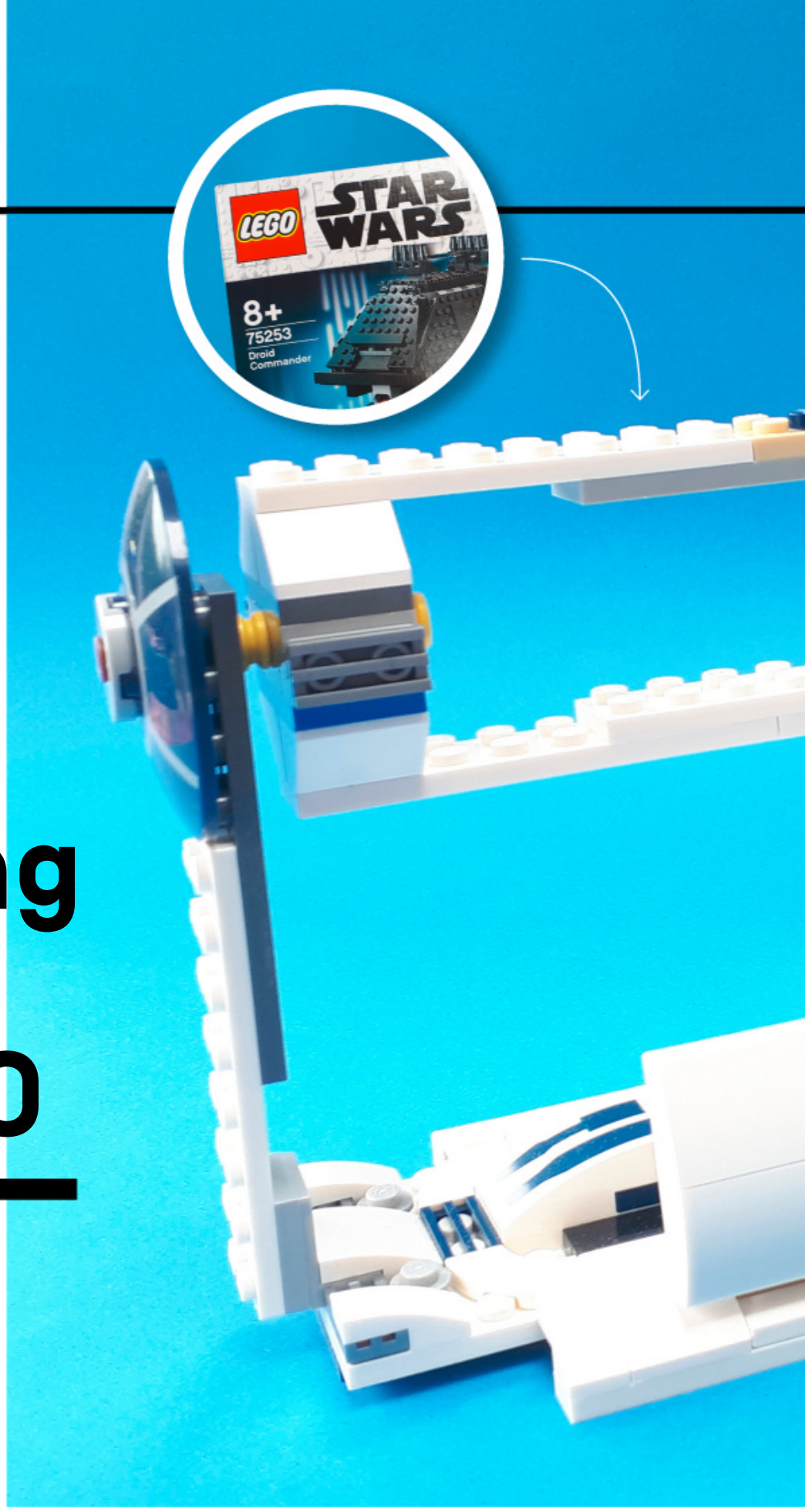
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// BY ANDREW DANIELS //

Reader Challenge: Build Something Useful With LEGO



THE MISSIVE TO *POP MECH* READERS, VIA Instagram, was this: Make something with LEGO that will make your (or someone else's) life easier, and show us the results. We weren't looking for the complexity or aesthetics you see in expert LEGO builds—even though those are awesome. We were looking for utility. Plastic bricks, Technic gears, and minifigures from existing kits were allowed, but we asked that builders steer clear of any instruction manuals. The job was to engineer your own solution. As one builder put it, "I just see any box of LEGO as a box of parts." Another worked from the same philosophy: "I love the concept of hacking items to get more uses out of something you already own."

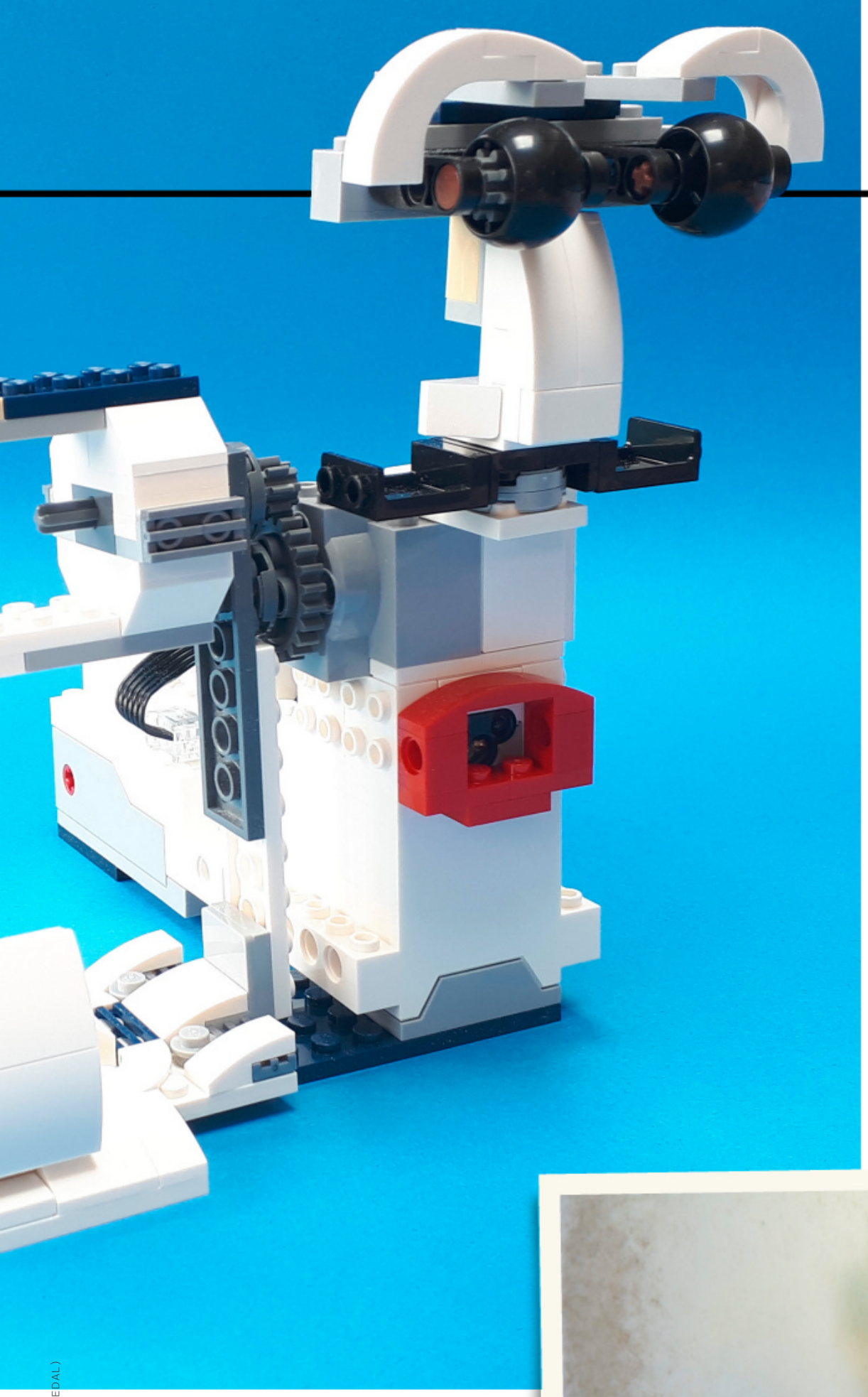
Of all the projects tagged for the #PopMech ProChallenge, here are a few of our favorites, and the story from their creators.

AUTOMATIC TOILET PAPER DISPENSER

The Builder: Steve Guinness
@thebrickconsultant

Guinness builds commissioned LEGO models for customers, and is the British *LEGO Masters* champ. "I dream in LEGO, wake up with new ideas, and head straight to my studio and get building," he says. But he saves his best ideas for family.

For this build, Guinness wanted to help his 11-year-old son, Obby, who had just broken his arm. When Guinness came across a LEGO Star Wars BOOST Droid Commander set, he found what he needed for an automatic toilet paper dispenser, including motors and motion sensors that you can control remotely with a program-



KICK DRUM PEDAL

The Builders: Aygul and Charlie Stevens @myn_syn

Aygul Stevens never learned how to build with instructions. Credit her inventor dad, who fashioned makeshift devices out of household items, like a toe shield built from toy metal construction pieces. Now, Stevens has passed on that DIY ethos to her 5-year-old son, Charlie.

When Charlie's teacher tasked him with building a musical instrument, he decided to make drums. For the pedal that powers the kick drum, he and his mom fetched a few gizmos from Charlie's Klutz LEGO kit—his edition was filled with tools that help kids learn about physics. With those parts, they built a system that pulls the pedal down, and moves the rubber ball head forward.

Naturally, Charlie enjoys making plenty of noise with his new gear—"but he loves the building stage [of a project] more than the playing one," Aygul says.



mable app. Once he designed the machine, the programming was easy: Instead of an on/off switch, he and his son set a distance for the motion sensor, so when they waved their hands in front of it, the motor automatically started.

They've since dismantled their TP device to concoct the next thing: a contraption that automatically winds spaghetti and feeds it straight into your mouth.

STEVE GUINNESS (TOILET PAPER); AYGUL IDIYATULLINA (PEDAL)

8 Pro Challenge

SHIRT BUTTONS

The Builder: Carley Lauder @offthepagelearning

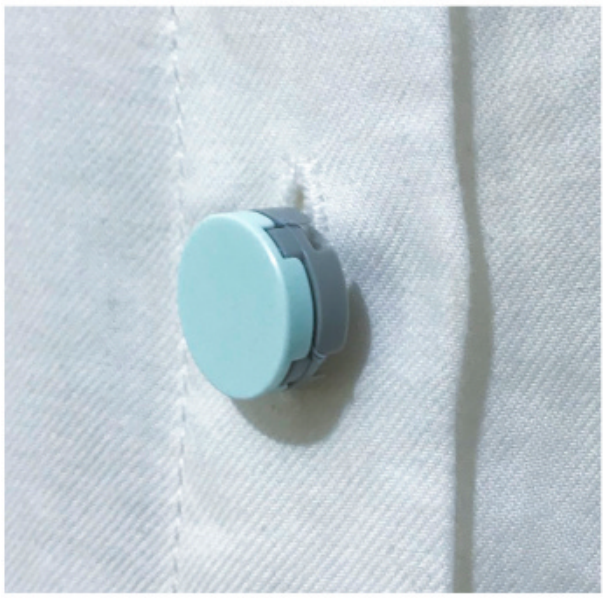
For years, Lauder, a Hong Kong–based educator, has made LEGO part of her classroom curriculum. "LEGO levels the playing field in play and conversations between kids and adults," she says. However, "many adult fans of LEGO make amazing models with skills, time, and money that I don't have—yet."

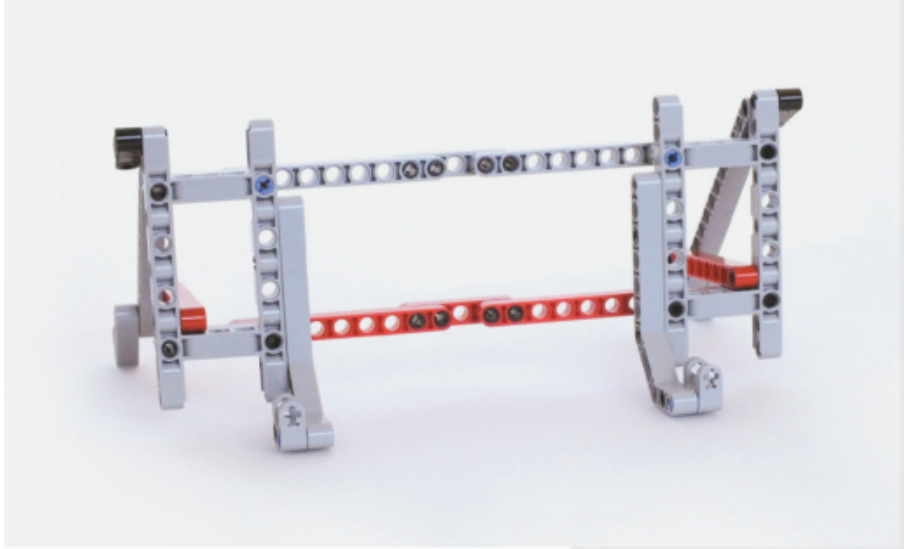
That's why Lauder, also an amateur seamstress, picked a deceptively simple project for this challenge: sewing round LEGO plates onto a collared shirt, and using them as buttons.

Lauder attached the light-gray plates—a color that's "not obviously LEGO until you get close up"—with four main stitches branching out from the center axle holes, and wrapped the thread around itself between the plates and fabric to form small shanks. The clever hack took one hour, tops.

"I love builds that do something as well as look awesome," she says.











TABLET STAND

The Builder: Siddhaant Gajendra @sidg_06

When his college campus closed due to the pandemic, Gajendra, an architecture tech student, suddenly found himself reimagining his home workspace. "I like things to work the way I want them to," he says. And there was one obvious problem: His tablet wouldn't stay upright, where he could see it. It kept sliding down, interrupting his studying. So he devised a solution.

Using Technic parts, Gajendra grabbed various length beams, pegs, and frames, and got to work. To build a sturdy support base that would stop the tablet from slipping without obstructing the view, he found a few C-shaped parts that fit just right. And when the parts that connected the stand's rear leg to the main frame were a bit longer than necessary, Gajendra used those pieces to fine-tune the slant of the stand for the best possible viewing angle.

It was a straightforward fix that settled a pesky problem. "I wanted to showcase the effectiveness of simple designs," says Gajendra. "Things do not have to be complicated to work." PM

CARLEY LAUDER (BUTTON); SIDDHAANT GAJENDRA (HOLDER)

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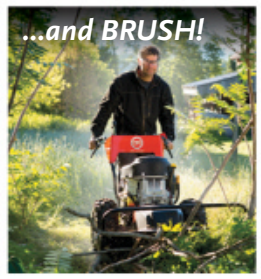


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▲ The Babylonian Map of the World, etched in the 6th century B.C.

THE

HISTORY of MAPS

The map has no single origin or known inventor. But these breakthrough maps illuminate the milestones of science and discovery that guided civilizations—and define how we view the world today

BY MEGHAN NEAL

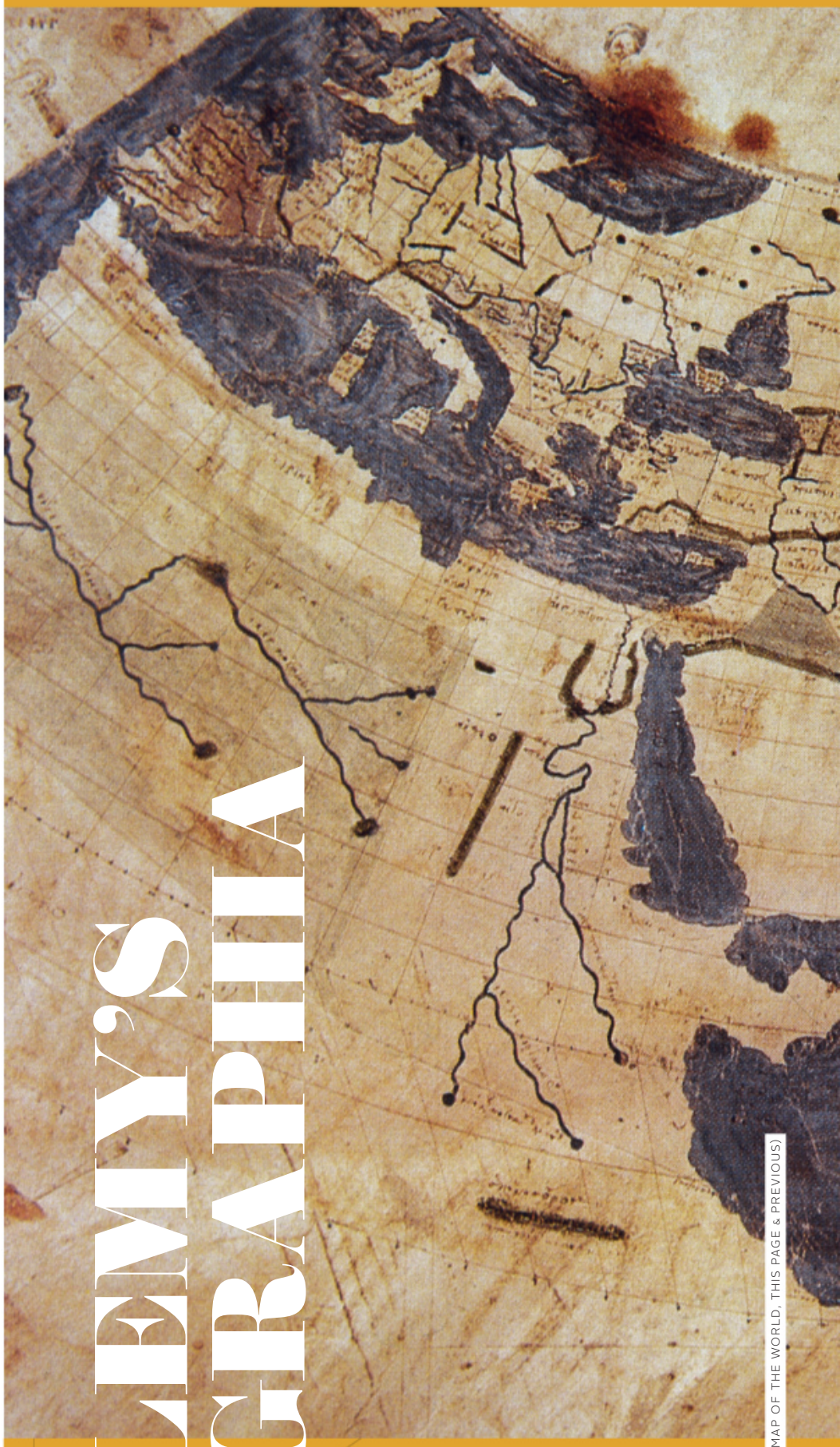


BABYLONIAN MAP OF THE WORLD

THE OLDEST SURVIVING WORLD MAP

The oldest surviving world map depicts the worldview of Babylonians circa 600 B.C. The 5-inch stone tablet is centered around Babylon, the wide rectangle, which straddles the Euphrates River, depicted by the crooked lines running from top to bottom. Babylon, likely the world's most populous city at the time, is surrounded by neighboring cities represented by small circles, all within a greater circle to denote the ocean. Though its geography is limited, this map reveals the inherent bias of mapmakers to place themselves at the literal center of the world.

Other early maps served more practical needs, such as the stick and shell charts built to denote currents around islands in the South Pacific over 2,000 years ago, or the Egyptian papyrus maps that led miners through the desert in the 12th century B.C. But the Babylonian Map of the World is the earliest example of a political map used to champion a country or city.



PTOLEMY'S GEOGRAPHIA

THE FIRST WORLD ATLAS

The Greeks were the first known culture to apply a scientific approach to measuring and mapping the world. The philosopher Pythagorus theorized as early as the 6th century B.C. that the Earth was round. And by 200 B.C., the scholar Eratosthenes compared the angles of shadows cast simultaneously in two distant cities to accurately esti-

FINE ART IMAGES/HERITAGE IMAGES/GETTY IMAGES (BABYLONIAN MAP OF THE WORLD, THIS PAGE & PREVIOUS)



▲ No original maps from *Geographia* survived, but this, the oldest recreation, was constructed in the 14th century according to Ptolemy's map projection and locations.

PHAS/UNIVERSAL IMAGES GROUP VIA GETTY IMAGES (GEOGRAPHIA)

mate the planet's circumference within 1,000 miles.

Combining the work of earlier Greek scholars with travelers' stories and town records from across the then-Roman world, Greek-Egyptian astronomer Ptolemy compiled *Geographia*, an eight-volume atlas that formed the basis for the next 1,500 years of mapmaking. Completed around 150 A.D., *Geographia* served as a how-to manual for cartography. Ptolemy explained map projections—depicting a globe on a flat plane. And he listed the coordinates for 8,000 locations in the recorded world—at the time, Eurasia and northern Africa—based on parallels of latitude and meridians of longitude, a precursor to today's system.

Maps based on Ptolemy's blueprint for the shape and size of the world informed Columbus's voyage to the Americas and led Ferdinand Magellan's expedition around the globe. Yet his work disappeared with the fall of the Roman Empire, not reemerging for almost 800 years.



TABULA ROGERIANA

AN UPDATE FOR THE NEXT MILLENNIUM

▶ The *Tabula Rogeriana*, or *Book of Roger*, was completed by Moroccan cartographer Muhammad al-Idrisi in 1154. Compiled over 15 years for King Roger II of Sicily—who hoped the map could inform and expand his rule—the book included a world map with 70 regional maps, each accompanied by a detailed description of their cities, roads, rivers, and mountains. For the next three centuries, it was among the most accurate geographic works in existence of the known world. It later helped guide Vasco da Gama's voyage to India by sea.

Though it was produced for a Norman king in Italy, the atlas was a culminating achievement from the Islamic Golden Age—while science took a sabbatical in most of Europe during the early middle ages.

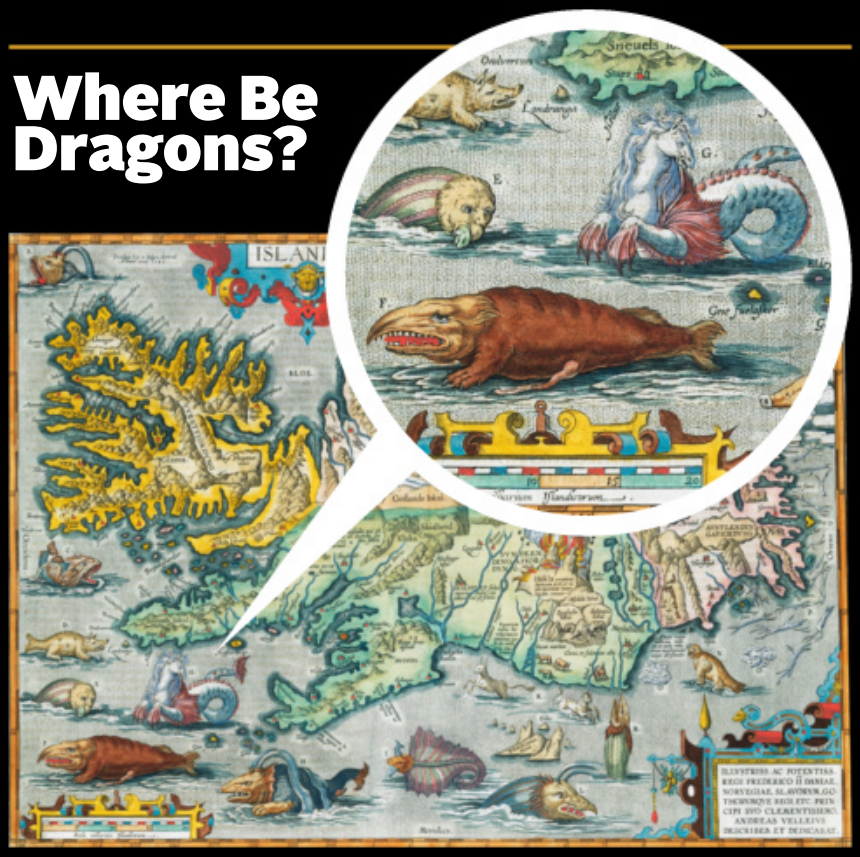
Al-Idrisi's work was in large part based on *Geographia*, which was rediscovered and translated into Arabic around the 9th century. Islamic cartographers built on Ptolemy's work and corrected errors based on their knowledge of the growing empire. They accurately drew the Indian Ocean as open and connected to the Pacific Ocean, instead of Ptolemy's landlocked sea.

Islamic mapmakers also produced some of the most elaborate charts of the era, largely inspired by the need to determine the direction of Mecca from anywhere in the world. Islamic world maps were oriented with south at the top, looking "up" toward the holy city.

FINE ART IMAGES/HERITAGE IMAGES/GETTY IMAGES

◀ Drawn by Muslim cartographer Muhammad al-Idrisi, this map of North Africa and Eurasia places south, the direction of Mecca, at the top.

Where Be Dragons?



FINE ART PHOTOGRAPHIC LIBRARY/CORBIS VIA GETTY IMAGES

The famous warning "Here Be Dragons" is a map myth: It was never actually written on old maps, though a Latin version appears on one 16th-century globe. Instead, the phrase represents the illustrations of monstrous sea serpents, toothy beasts, and strange peoples that frequently adorned medieval and Renaissance maps.

In most cases, map monsters were simple decoration, strategically filling in the empty parts of the map. (Cartographers are known to abhor a blank space.) But often, these imaginary beasts were seen as very real threats, born out of inflated travelers' tales and infused with religious myth and folklore. They were often drawn lurking in uncharted waters, where they signaled the dangers that lie beyond the known world.

On some medieval world maps, the inhabitants of distant lands are depicted as strange mythical peoples. You'll find the headless "blemmyes" with faces in their chests, the desert "sciapods" with a single giant foot to shield the sun, and the "antipodeans" who live on the other side of the world (the Australian continent from the Europeans' perspective) and whose feet point in the opposite direction.

CATALAN ATLAS



▼ The two far right pages of the Catalan Atlas (pictured) depict central and eastern Asia based on Marco Polo's travels.

NAVIGATION BY COMPASS

▶ Ancient sailors navigated the seas by keeping in sight of land and observing the sun and stars. If clouds rolled in, they pulled in their sails and waited for better visibility.

The discovery of the compass—a magnetized needle on wood, floating in water, aligning itself with the magnetic poles—changed navigation. Sailors could safely venture into the open sea without visual cues.

First mentioned in 11th century China, the compass spread along the Silk Road connecting the East and West, and with it, a new type of European map came into vogue, called a portolan chart. These nautical maps were covered in crisscrossed lines indicating the bearing of trade routes between ports. The oldest surviving example, the Carte Pisane, dating to 1290, charts the Mediterranean and Black Sea with enough accuracy that ships could navigate with it today. But the most famous and expansive portolan map is the Catalan Atlas. Drawn over eight pages of vellum in 1375 by Majorcan cartographer Cresques Abraham, it was the first world map to include the compass rose and stretched from the western edge of Europe and North Africa to China's eastern coast.

DE AGOSTINI PICTURE LIBRARY/GETTY IMAGES

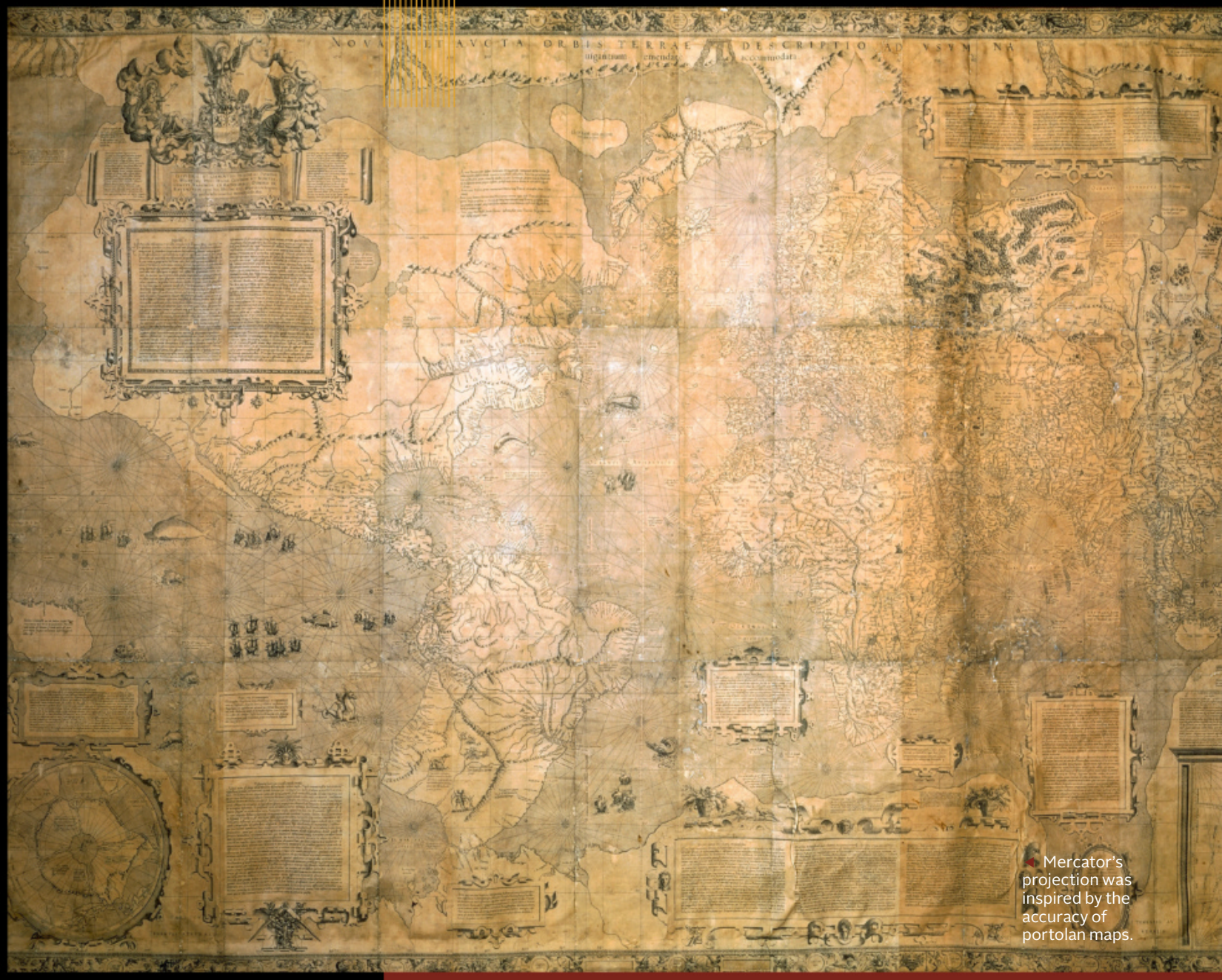
MERCATOR MAP OF THE WORLD

THE FIRST MODERN MAP

The compass sparked a shift back to geographical maps made for practical navigation. Religious symbolism defined most medieval European mapmaking. (Maps could tell you the rough direction of Eden, but not how far away it was.) In the early 15th century, European monarchs began to explore the Atlantic and Indian Oceans in search of new trading routes to the East. At the time, Ptolemy's *Geographia* was translated into Latin, marking the start of a boom in exploration and mapmaking.

As the 16th century saw the most complete maps of the world, it also overcame one of the thorniest problems of cartography: how to navigate a spherical globe on a two-dimensional map. Picture flattening an orange peel against a flat surface—it's impossible to do so without distorting its shape. Ptolemy had tackled this, but navigators still couldn't achieve the simple task of plotting the shortest course between points on a map with a straight line.

In 1569, Flemish-German cartographer Gerardus Mercator solved this millennia-old problem with a new map projection: Earth as a cylinder, which unrolled to a square grid of latitude and longitude. The projection spaced lines of latitude increasingly far apart as they got farther from the equator. The disadvantage of this projection, which we still see today, is that it distorted landmasses toward the poles. Eurasia and North America are enlarged, while regions at the equator, such as most of Africa, appear misleadingly small.



Mercator's projection was inspired by the accuracy of portolan maps.

DEA PICTURE LIBRARY/DE AGOSTINI VIA GETTY IMAGES

AERIAL MAP OF MANHATTAN

MAPPING FROM ABOVE

The first photograph taken from the air was shot from a 260-foot-high hot air balloon in 1858. It was an inauspicious start—and that photo of a small French village was lost—but aviation would revolutionize mapmaking. From above, a photograph could gather a huge amount of data at a time, a major improvement on labor-intensive ground surveys.

When World War I broke out, maps became powerful weapons. A detailed trench map of the front line allowed for artillery bombardments to be carried out without practice shots, retaining the element of surprise.

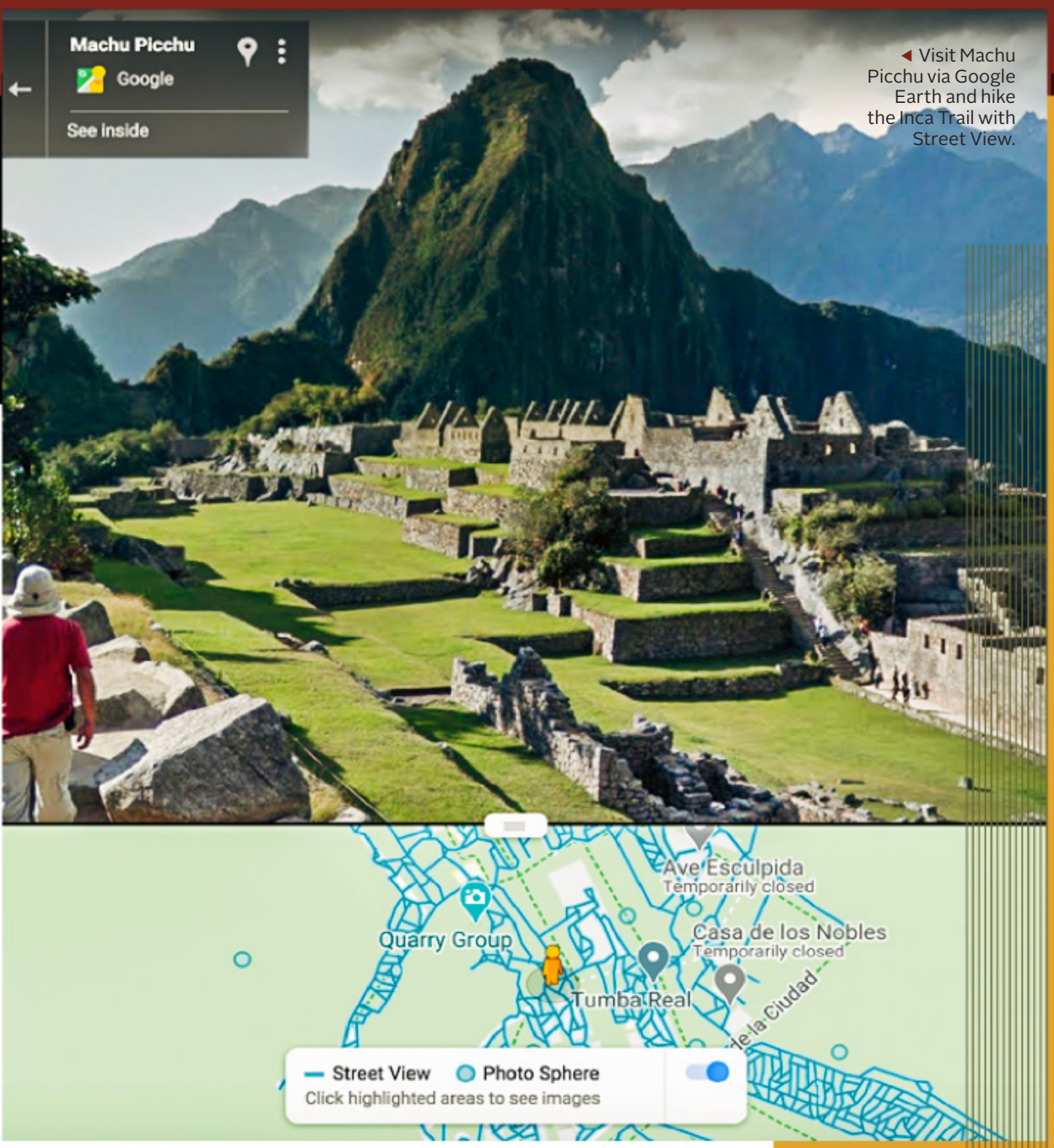
After the war, aerial photography spread to civilian use and the Fairchild Aerial Map of Manhattan ushered maps into pop culture consciousness. New York City entrepreneur Sherman Fairchild, who had been developing new aerial photography techniques for World War I, introduced an aerial camera that automatically snapped photos and turned the roll of film at timed intervals.

Mounted under a war-surplus biplane flying 10,000 feet high over New York, the camera snapped photos of the city every 27 seconds over a 69-minute flight up and down the island. The negatives were then overlapped to form the detailed Manhattan grid with a precision that set the standard for the next 50 years of aerial mapping.



▲ Manhattan was Fairchild's second first aerial survey. His first, a map of Newark, New Jersey, failed to gain notice.

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◀ Visit Machu Picchu via Google Earth and hike the Inca Trail with Street View.

GOOGLE EARTH, MAPS, AND STREET VIEW

THE WORLD, IN YOUR POCKET

▶ The Cold War drove the next leaps in mapping technology. The launch of Sputnik sparked the development of GPS when MIT scientists realized they could track the Soviet satellite from the ground by observing how its radio signal changed as it moved, and likewise, objects on Earth could be located based on their distance from satellites.

Early satellite navigation experiments were developed by the U.S. military to track intercontinental missiles in the 1960s. And by the early 1970s, the military launched the first Global Positioning System, NAVSTAR, which could determine precise spatial coordinates for anywhere on Earth. Today a full constellation of GPS satellites (about 27) circles the globe twice a day, transmitting radio signals. When an object on Earth's surface receives a signal from at least three satellites, its precise geographic coordinates can be determined within centimeters.

In 2000, the Department of Defense lifted its policy of degrading the accuracy of its GPS tracking for civilian use. From the ensuing technology boom, Google emerged with a trio of products—Earth, Maps, and Street View—that together created the most complete world map.

Released in 2005, Google Earth provided an interactive, 3D image of the globe formed from millions of overlapping satellite photographs overlaid on a 3D digital earth. Close-up 3D details are added from aerial images that capture the depth of buildings and terrain.

Started in 2006 with vans driving around six major U.S. cities with GPS sensors and multi-lens cameras mounted on top, Google Street View recreates the Earth from eye level. In 2017 the Street View cameras were updated with laser scanners that record the dimensions and depth of the objects being photographed to create a 3D view along the way. These cameras, aided by crowdsourced data and machine learning, have mapped millions of miles of roads across 87 countries on all seven continents. Combined with Maps, Street View and Earth literally put the world in billions of people's hands. It is now possible to navigate and explore nearly anywhere on Earth—try Everest Base Camp or Rome's Coliseum—with a click and zoom. PM

GOOGLE STREET VIEW

THE FUTURE OF OFF-R

ELECTRIC SUPREMACY IS indisputable: More power, immediate torque, superior ground clearance, and in-hub motors commanding each wheel make electric vehicles (EVs) ideal for a demanding go-anywhere adventure compared with diesel- or gas-engine vehicles.

EVs' in-hub motors are optimal for all-wheel-drive traction and handling, and trucks' high ride height affords graceful incorporation of a floor-mounted battery pack. The lack of other underbody components like exhaust pipes or gas tanks grants EVs better ground clearance than gas-engine trucks, and thanks to zero emissions from the tailpipe, your adventures will be more eco-friendly.

For truck buyers weaned on V-8s, these pickups defy the sparing output of other EVs. "These are muscle trucks—they're monsters," says Ed Kim, vice president of industry research firm AutoPacific.

In-hub motors are one of the keys to EVs' powerful potential. While a gas-driven engine runs from the front of the vehicle to the axles, an in-hub motor resides individually in each wheel's hub. This more direct mode of power delivery offers greater precision and efficiency, and thanks to the motors' simple design and fewer parts, they're cheaper to maintain than a traditional engine.

Placing in-hub motors at the truck's corners also liberates designers from the three-box layout of a traditional pickup, but these early models still skew old-school, turning the nose's "engine" compartment into extra storage. In the future, e-trucks might not appear like classical trucks at all.

RIVIAN R1T

Leader of the EV pack

PRICE: $69,900+

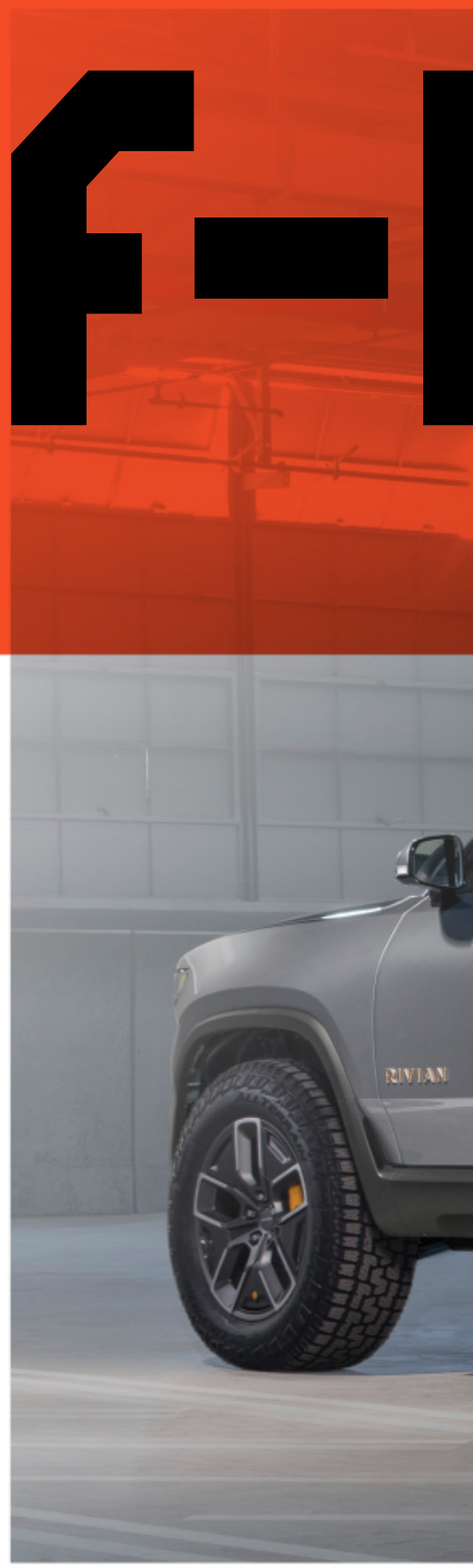
RANGE: 230–400 miles

RELEASE: Early 2021

THE RIVIAN R1T WILL BE THE FIRST EV truck to reach the market. Set for early 2021, the four-door features up to 750 hp, 829 lb-ft of torque, a quartet of in-hub motors, and a battery pack upgrade for 180 kWh—the most power we know of in this crop. The peak setup provides a projected 0-to-60 time of 3.0 seconds, 400 miles of range, and an 11,000-lb towing capacity—enough to pull a 35-foot travel trailer. The base 105 kWh, 230-mile range R1T will cost $69,000, per Rivian, with more pricing details to come.

In the field, adjustable power delivery to individual wheels provides intense grip for the R1T in slippery conditions, and an adjustable air suspension system combines sportscar-like roll stiffness with dune buggy–esque impact absorption. The R1T links its right-hand compression circuits with its left-hand rebound circuits, same with the front and back, to minimize impact, and compared to active hydraulic suspension, it uses far less energy, minimizing impact on battery range.

In addition to a "frunk" under the hood, the R1T sports a pass-thru "gear tunnel" between the bed and rear doors. Rivian will produce adventure modules like a camping kitchen, cooler, and tackle kit for the tunnel. A cloud-connected infotainment system up front incorporates on- and off-road maps, too.



Road Is



ectric

BY BRETT BERK

BOLLINGER B2
Built to Work

PRICE: $125,000

RANGE: 200 miles

RELEASE: Late 2021



MICHIGAN STARTUP BOLLINGER Motors takes a retro-modern approach with their $125,000 B2. Its rectilinear design features sharp corners outside, powder-coated switches within, and a total absence of screens or driver-assistance tech. Bollinger will be the only electric truck in this group to produce a bed-less cab-on-chassis version, adaptable into a box truck or tow truck.

The B2 focuses on ultra-off-road capability, combining military transport-esque portal gear hubs with a height-adjustable hydro-pneumatic suspension, offering a class-leading 20 inches of ground clearance. Translation: fewer instances where you'll have to stop and turn around before an obstacle in the road. The B2 hosts a 120 kWh battery pack, and front and rear motors that drive all four wheels—good for 614 hp/668 lb-ft of torque. That powers the B2 from 0 to 60 in 4.5 seconds and provides a 200-mile range. If the Rivian is a Swiss Army knife, this is a machete.



GMC HUMMER EV

1,000 HP? 1,000 HP!

PRICE: N/A

RANGE: N/A

RELEASE: Fall 2021



GENERAL MOTORS HAS YET TO UNVEIL THE 2022 GMC HUMMER EV, ITS FIRST ELECTRIC TRUCK, but early details indicate the company is reviving its profligate nameplate for a 1,000 hp all-wheel-drive electric pickup capable of a 3-second 0-to-60. Meanwhile, Ford is being similarly tight-lipped about its forthcoming F-150 electric, besides that it'll be released "in a few years." Expect both of these trucks to be more mainstream plays, electric Trojan horses designed to lure in traditional pickup buyers to this nontraditional category.

EV JUGGERNAUT TESLA'S entry in the category is the outrageous, apocalyptic Cybertruck. It boasts class-leading capacity with seating for six, an unmatched 500-mile range, up to 14,000 lbs of towing capacity, and loads of lockable storage, including its retractable "vault" (Tesla-speak for bed) cover. The truck's planar body panels are scratch- and dent-resistant cold-rolled stainless steel. Expect blistering acceleration in the top trim, with 0-to-60 times of less than 2.9 seconds for the tri-motor variant. For an additional $7,000, Elon promises "full self-driving" capabilities—apparently for those who don't want to do their own dirty work. PM

TESLA CYBERTRUCK

"Fury Road" Goes Electric

PRICE: $39,900–$69,900

RANGE: 500 miles

RELEASE: Late 2021



COURTESY RIVIAN (PREVIOUS SPREAD); COURTESY BOLLINGER; RADOVAN VARICAK (HUMMER); COURTESY TESLA



PROP STYLING BY MICHELLE MAGUIRE

The Race to Make Cell-Grown Meats Mainstream

BY
Jenny Splitter

PHOTOGRAPHY BY
Kelsey McClellan

ON AUGUST 5, 2013, CHEF RICHARD McGeown was in London, preparing to film a cooking segment on British television. McGeown was searing a burger, something he'd done countless times before. But this time, an estimated billion people would be watching or reading about what was about to transpire. Because the round, pink mass McGeown was cooking was a $325,000 burger made from stem cells cultivated in a lab by scientists in the Netherlands.

"It's close to meat," said Hanni Rützler, a food trend researcher who tried the so-called in-vitro patty. But, she noted, it lacked fat and juiciness. Perfection wasn't the goal for Mark Post, the lead scientist behind the burger. "This is just to show we can do it."

Futurists have imagined growing meat from cells for decades. In an essay containing his predictions for a world fifty years beyond its 1931 publication date (republished in the March 1932 issue of *Popular Mechanics*), Winston Churchill described a future where we "escape the absurdity of growing a whole chicken" in favor of a lab-grown breast or wing.

We're still probably a decade away from lab-grown hot wings, but cultured chicken nuggets and burgers might be available in the next two years, says Kate Krueger, PhD, a cell biologist and the director of research for New Harvest, an organization that funds cultured meat research. Initially, those products will probably appear in restaurants, but eventually they'll hit grocery stores.

Still, chasing cultured meat is "a bet," concedes Josh Tetrick. The 39-year-old is the CEO and co-founder of Just, an eight-year-old San Francisco company that makes a plant-based mayonnaise and an egg scramble made from mung beans. Now, Tetrick is hell-bent on proving that cultured proteins alone, not plant-based substitutes, have the unique ability to completely replace conventionally farmed meat in our diet.



▶ Futurists have imagined growing meat from cells for decades.

The cells that comprise a cultured steak are nearly identical to those in the meat from a butchered cow. Both are made of animal tissue, with very few differences. In other words, as Tetrick says, cultured meat is real meat.

PAOLA BIGNONE, PH.D., SENIOR research scientist on Just's Cellular Agriculture team, peers into a microscope under a fume hood in one of the company's cultured meat labs. The lab looks like any other research facility, lots of white and stainless steel. But what happens in this lab is anything but ordinary. The team keeps mum on many of the particulars of the growing process, especially the nutrient cocktail that is fed to the cells, because the cost and efficacy of that cocktail are what will undoubtedly determine which of the 20-plus companies that are working on cultured meat will win the race to market.

The process of making cultured meat is actually much closer to the process of growing organs for transplant than it is to raising and slaughtering conventionally farmed animals.

Bignone starts with a very small cluster of cells: All that's needed is a push pin-sized tissue biopsy usually taken from the muscle tissue of a live chicken. Though that first burger cooked in London came from cells from a dead cow, these days the source livestock are all very much alive. "We don't need to sacrifice the animal," says Vítor Espírito Santo, PhD, the Director of Cellular Agriculture for Just, who leads the company's cultured meat team. "The tissue samples can be taken out in a way that's fairly painless" using local anesthesia, says New Harvest's Krueger. "They don't feel anything and they're happily back out in the field that very day." And you can grow quite a bit of meat from just a few cells, says Santo.

The first part of the culturing process is isolation: separating the satellite cells—adult muscle stem cells that can divide to create more muscle cells—from the rest of the tissue. To coax these cells out, Bignone places the biopsied tissue in a container with a proprietary mix of salt, sugar, and proteins. The container is put into an incubator the size of a mini-fridge that mimics the temperature and movements of a growing animal's body.

The next step in the process is growth. Santo says the scientists feed the cells much like a farmer would feed an animal. But instead of dump-



ing grass or grain into a food trough, labs techs bathe the cells in a liquid solution that contains proteins, sugars, vitamins, "a cocktail of different nutrients that are also available in the animal's body," says Santo.

Cultured meat researchers initially fed all cells fetal bovine serum, a thick, nutrient-packed fluid made from tissue extracted from a slaughtered calf. But in addition to being expensive, the serum poses an obvious conflict for an industry that's positioned itself as an alternative to conventional animal farming. That's why all of Just's cultured meats are serum-free.

Santo points to several clear lab flasks about the size of a half-gallon of milk. Each is partially filled with the initial red liquid "food." As the cells grow and proliferate, the team changes the recipe of the liquid nutrients to boost growth. These starter cells continue to grow in a petri dish until they differentiate into a more mature, fibrous muscle tissue.

We're probably still a decade away from lab-grown hot wings, but cultured burgers might be available in the next two years.

Scientists can cultivate the differentiated cells into the exact texture and structure they want in their meat, either using one of the small bioreactors they have in-house or using one of the larger ones they have at their offsite facilities. During this stage they

ALSO ON THE MENU OF THE FUTURE

INSECTS
Most common types for human consumption are the Acheta and the banded cricket, says Jarrod Goldin, president of Canada-based insect farm Entomo Farms. Packed with a nutty, earthy flavor, crickets are rich in protein, prebiotic fibers, and antioxidants.

ALGAE
Triton Algae Innovations's proprietary strain of algae boasts flavor-mimicking properties—think savory flavors of meaty foods and salty notes of umami. "It runs about 45 to 50 percent protein, has a complete amino acid profile, and is rich in vitamin A and iron," says David Schroeder, director of corporate and regulatory affairs.

ANIMAL-FREE EGG WHITES
Clara Foods converts sugar into proteins, which are then encoded with 3D-printed genes that code for the same proteins found in an egg, explains CEO Arturo Elizondo. One strain produces a baking albumen; another generates a soluble mix for drinks.

3D FOOD PRINTING
With the aid of a precision tech system, preloaded shape libraries, and customizable print nozzles, 3D printer Foodini prints with fresh ingredients. "[These printers] don't require arable land, fixated CO_2, or regular feed, and require far less water," says food designer Chloé Rutzerveld.
—Leah Campano

can also add more fat or other ingredients to boost flavor. The duration of the process varies, too—up to eight weeks or more, depending on the protein.

Just receives cells from some of the most prized animal farms in the world, including a Wagyu beef operation called Toriyama Farms located in Gunma, Japan. Tetrick talks about the beef in glowing terms: "It has the best umami [flavor], the best texture, the best color." The Wagyu is the flashiest protein in Just's wheelhouse, but the company's fastest-growing cells come from a chicken, which is why the company's first cultured meat product will be chicken nuggets, not a Wagyu burger. Santo says the first nugget will probably be sold at one or two high-end restaurants in Asia, possibly as early as this year, as the company has been in discussions with government regulators in countries there for several years.

Once Just gets better at making cultured meat on the cheap, however, Tetrick says you can expect to see more of these once-exclusive proteins. "I think the future of cultured meat is premium meat like Wagyu and bluefin tuna," he says, because in the world of cultured meat, those few initial cells aren't the main cost, the growth factors are. "It's actually not any more expensive to take a cell and then scale that cell up from the world's most expensive cow than the world's cheapest," he explains.

BEING ABLE TO EAT WAGYU ON A ground chuck budget isn't the only upside to cultured meats. Getting Americans to eat less conventionally farmed meat, especially beef, is also an environmental win, says Caroline Grunewald, a food and agriculture analyst at the Breakthrough Institute. Raising beef and other ruminant meats like lamb produces much higher greenhouse gas emissions than other proteins like beans and nuts, and these emissions are major contributors to climate change. Researchers compared how much GHG emissions conventional beef production currently produces with how much cultured meat is expected to produce at the same scale, and found that cultured meat production would likely result in lower emissions.

Cultured meat doesn't require antibiotics beyond the initial tissue isolation to keep an animal healthy, either, which means it could help drastically reduce the spread of antibiotic-resistant bacteria associated with conventional chicken and pork production. And with no animal waste, there's much less risk of an outbreak from pathogens like *E. coli* (assuming the company's production facilities can match the pristine conditions of a laboratory).

It will also likely take less land to produce cell-based meat. That's important because certain types of land, like forest, serve as "carbon sinks," which means they keep carbon trapped in the vegetation and the soil rather than releasing it into the atmosphere where it amplifies greenhouse



“I think the future of cultured meat is premium meat like Wagyu and bluefin tuna.”

heating. When you clear forest to produce something like beef, or grain used to feed beef, you release more carbon, explains Tim Searchinger, a research scholar at Princeton University and a Senior Fellow at the World Resources Institute, an organization that researches environmental issues like sustainable food production.

It’s early days for cultured meat, so most of the research about an industry that isn’t producing at scale is, of course, somewhat speculative. As technologies like solar power become more efficient, cultured meat proponents say the industry has an even greater potential to lower its greenhouse gas emissions and be better for the planet.

CHEF JOSH HYMAN WAITS FOR A small pot of oil to heat up in the test kitchen before dropping in a single frozen cultured chicken nugget. It looks like any other nugget purchased in the freezer aisle of a grocery store: a clump of ground chicken that is breaded, flash-fried, and frozen. As we chat, Hyman reflects on one of Just’s earliest tests.

The scientists had rushed upstairs from the lab with about a teaspoon-sized clump of cells that looked like ground chicken and asked him to cook it. When Hyman pan-fried that first bit of chicken, it was tasty. Tender. Their next step was a comparison test: “We made two veggie burgers,” he says. “We added cultured chicken to one and we left the other one alone.” As the burgers cooked, something happened in the room, according to Hyman, who sniffs at the air to demonstrate. Colleagues rushed over to ask if they were cooking meat, which proved they’d nailed the aroma. As the burgers cooked, “you could see that Maillard reaction,” says Hyman, referring to the browning



▼ The lab growing process could bring down the cost of exclusive proteins like bluefin tuna.



Cultured meat is still pretty expensive—the current cost of a single nugget made by Just is around $50.

chemical reaction that happens to meat and other foods. The taste difference between the two was "night and day," says Hyman. The chicken-veggie blended burger was so much more juicy and delicious, like a real chicken burger. "That was kind of the click, when we understood what we were working with," he says.

"This is close to the final formulation," Hyman tells me as he lifts the crispy nugget up out of the oil with a wire skimmer and drops it onto my plate to cool. "But…we're still tweaking here and there." I slice the nugget in two; it's white on the inside, sort of



crumbly, almost like a small, white chicken burger. I take a bite: first, crisp breading. Then, sinking deeper into it, the nugget tastes like a light pillow of perfectly seasoned ground chicken, far better than a hockey puck–hard fast-food nugget.

Lou Cooperhouse, President and CEO of BlueNalu, a cultured fish company that reportedly raised $4.5 million in 2018, isn't a disruptor like Tetrick. He's a self-described food industry guy who came to the cultured meat business with decades of food processing experience, which means he recognizes one of the major hurdles

◀ Companies still face the challenge of scaling cultured meat production.

faced by lab-grown meat: scalability. But if the industry can solve that problem, Cooperhouse thinks cultured meat is the perfect solution for the entirely unpredictable world of fish supply. Each season, the supply surges or falls at the whim of the planet. Something like increasing ocean temperatures or plastics in the ocean can do significant damage to a wild fishery, leaving fewer fish to sell to restaurants or markets. You remove all of that risk by culturing fish rather than catching it in the wild, says Cooperhouse.

Cultured meat is still pretty expensive—the current cost of a single nugget made by Just is about $50—because the growth factors scientists feed the cells are both difficult and expensive to make, says New Harvest's Krueger. Just and BlueNalu are figuring out how to bring these costs down while making plans to build their factories, which Cooperhouse describes as something like "a microbrewery meets a traditional food processing facility." "The production systems that we use at scale look more like fermenters," explains Just's Santo, "because we actually use similar processes to make beer, wine, or cheese. The only difference," adds Santo, "is that the starting material is the animal cells"—and instead of fermenting the cells, they're growing them in bioreactors.

Companies also have to negotiate with government regulators to make sure they can actually sell their products. Santo says the company hopes to be able to share some news on that front "soon," but for now they're happy with the FDA and USDA announcement of a regulatory framework for cultured meat in March.

Even if companies can work out scale, cost, and regulatory kinks, they still have to convince consumers that cultured meats are worth eating. Alex Trembath, Breakthrough's Deputy Director, has written about the backlash to what he likes to call "fake meat." There's trepidation—and even a bit of revulsion—to meat grown in a lab. Trembath gets it: When he made meatballs out of "meat" from Impossible, he was "sort of grossed out" by how gooey and strange it felt in his hands, even though he's "perfectly fine handling ground-up cow carcass." Trembath says the feeling is "very 'uncanny valley,'" a theory that describes the sense of revulsion inspired by robots that look almost exactly like humans but, at the same time, just a little bit different.

A person's comfort level with this stuff may depend on how they encounter it—a 2019 study found that individuals felt more negatively about cultured meat and less likely to consume it when framed and depicted in images as something high-tech, rather than being characterized as "same as meat" or for "societal benefits"—and what companies end up calling it. Cultured meat has already gone by a number of different names, including clean meat, in vitro meat, lab meat, and vat meat, none of which sound very appetizing. The industry faces an uphill battle at the moment—"No, no, don't call it lab meat," Cooperhouse protests—but most consumers don't know what "cultured meat" is, at least not yet.

Tetrick knows it will probably take a long time to escape our aversions. But if Just can bring down the price of a cultured Wagyu beef patty, he thinks more chefs will be willing to serve it on their menus. And if the meat is cheap enough and the chef tries it, Tetrick starts to like his odds. "It's just better tasting. It's more umami. It's deeper. It's richer," he predicts, and then the kicker: "I think my customers would like it better."

As BlueNalu's Cooperhouse reminds me, much of the food we eat has been optimized by scientists, for better or for worse, whether it's grapes grown to taste like cotton candy or beef from cattle bred to be more docile for ease of slaughtering. If people can accept that and enjoy the pleasurable umami of a cultivated Toriyama Wagyu burger, Tetrick hopes they'll begin to ask another question: "Why do we also have this other thing [this conventional meat] on the menu?" And at that point, Tetrick will have won his bet. PM

GRIZZLY BEARS

BY **AMY GRISAK**

18+

WHAT IS AVAXHOME?

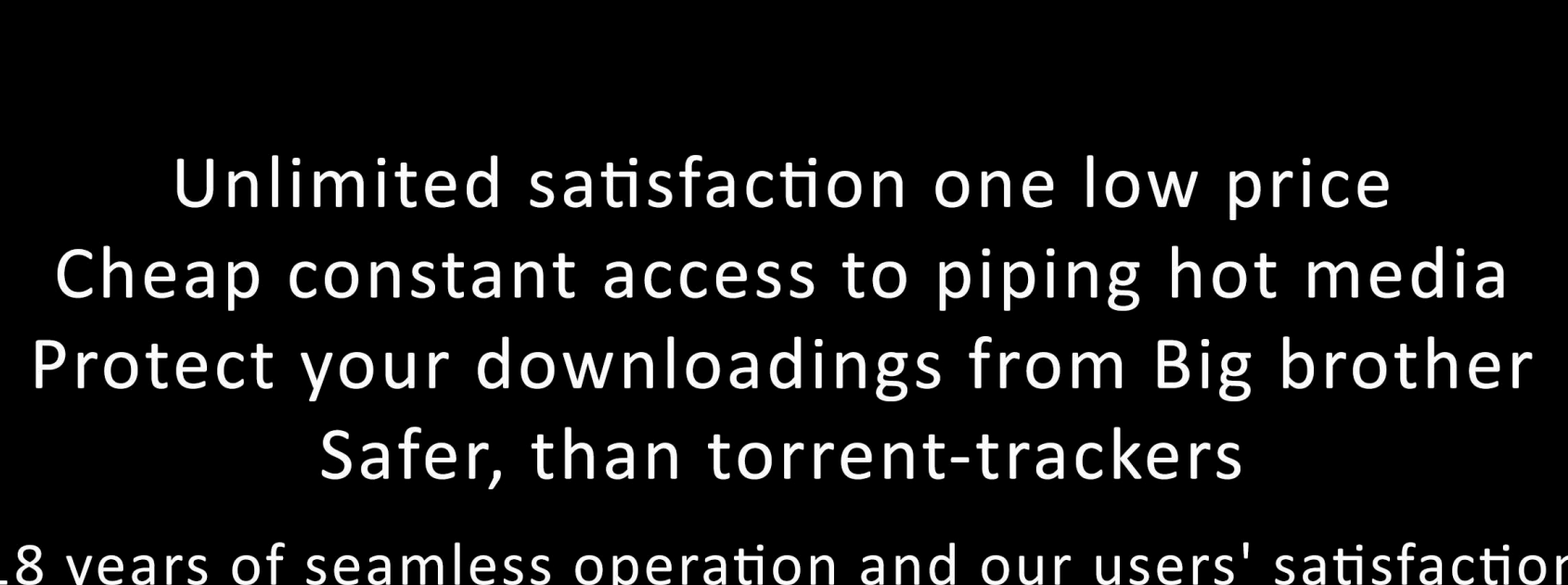
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In the last 15 years, the population of grizzly bears in northern Montana has grown by more than 50 percent and spread from the mountains to the plains.

ARE RETURNING
TO A HABITAT LOST
A CENTURY AGO.
THE ONLY PROBLEM?
WE LIVE THERE NOW.



THE FIRST GRIZZLY WAS FOUND LYING IN THE 15TH TEE BOX eating a maggot-infested carp like it was corn on the cob. The neighboring Marias River had flooded, Scott Lennemann, golf course superintendent at Marias Valley Golf & Country Club, told me. The retreating water then left behind a lunch buffet of dead carp, which the lucky bear feasted on.

I heard about Lennemann's golf course guest through the small-town grapevine that connects the scattered communities across the Montana prairie I call home. I knew—or thought I did—that the only big animals roaming the wide grassy valleys were steers fattening up to make next summer's BBQ. Sure, Montana had massive bears (up to 700 pounds), but in the Rockies. Marias Valley was in Shelby, Montana, 90 miles east of Glacier National Park, and fits the description of a home where buffalo used to comfortably roam.

Lennemann seemed justifiably surprised to see a grizzly bear in Shelby. But as I looked into why an apex predator had moved into farm country, I learned a startling fact: They were here first.

The giant omnivores—they will eat anything—have lived in the nearby Rockies and on the prairies far longer than Montana has existed. And their absence from the prairie is a manmade aberration from human encroachment and lost habitat, says Mike Madel. Officially, Madel is a grizzly-bear management biologist for Montana Fish, Wildlife & Parks. I went to Madel for answers because unofficially he's the closest thing our state has to a grizzly whisperer.

Grizzlies once ranged over nearly half of the United States. But by 1975, they'd been reduced to 2 percent of their original turf, including a pocket in Montana's northern Rocky Mountains. In response, the U.S. Fish and Wildlife Service designated the bears as a threatened species, and in 1983, six grizzly recovery ecosystems were designated in Idaho, Montana, Washington, and Wyoming, providing protection and habitat restoration for the bears. The Northern Continental Divide ecosystem, which covers roughly the upper half of Montana's Rockies, has steadily grown its population to more than 1,000 grizzlies. But the bears need space—a male grizzly may range over 500 square miles. So as their population grows, Madel says, it's natural that they expand into fringe areas, even if the species hasn't lived there for over a century.

Fortunately for the bears, they don't mind the changes we've made. Southwest of Shelby, in the town of Valier, bears are swimming in Lake Frances, a popular fishing spot stocked with walleye and pike. East of the lake, in Loma, they're talking strolls through yards. And in a few towns in between, they're trashing cornfields and breaking into poorly secured chicken coops.

Madel understands the shock of encountering a grizzly. And he's spent more than 30 years helping communities along the Rocky Mountain Front live, play, and adapt in grizzly habitat with minimal conflict. Getting along peacefully is entirely possible, he says, but it's on us. Bears will be bears.

Lennemann and his grounds crew have started working in pairs, carrying walkie-talkies, and training to use bear spray. "We've also cleared brush from the cart path," he says. While their golf carts top out at 10 mph, a grizzly can hit 35 mph, so he'd rather see a bear long before he can hear it crashing through bushes.

For the most part, the bears haven't posed a problem, outside of occasionally trashing flags and leaving claw marks on the fairways. And the golfers aren't noticeably fazed by the possibilities of grizzlies in the area, but they keep their

DANIKA PERKINSON/UNSPLASH (PREVIOUS SPREAD); TONY BYNUM (ROAD); AMY GRISAK (POLE); ALAMY (PRINT)



▲ One of Glacier National Park's more than 300 grizzlies.



▶ Glacier campsites have a pole to hang attractants.

eyes open. In 2018 the course had eight confirmed visits by grizzlies—its annual record—resulting in a few interrupted rounds but no close calls. It's a workable relationship.

I could relate to Lennemann's surprise at seeing a bear. Though at the time I lived outside West Glacier, smack in the middle of that recovery zone, it took a literal wake-up call for me to develop the proper neighborly rapport with the grizzlies: The guttural growl of R.D., my shepherd-Akita mix, snapped me out of a dead sleep. Stepping over him on the landing, I clicked on the light and stared through the window onto my porch—into the eyes of an adult grizzly licking my barbecue grill three feet away. Startled, the bear dashed away as quickly as I stepped back, but that rush beat the devil out of any cup of coffee.

WHAT TO DO IF YOU SEE A GRIZZLY

"Most likely they're going to go the other way," says Wayne Kasworm, grizzly bear biologist with the U.S. Fish & Wildlife Service. "They don't want anything more to do with us than what we want to do with them." But you should have a plan for when an encounter is unavoidable.

MAKE YOURSELF KNOWN

Talk (don't yell) to alert the bear to your presence as you slowly back out of the area. If a bear is too close or doesn't leave, do not run—that signals that you're prey.

CARRY BEAR SPRAY AND KNOW HOW TO USE IT

"Most charges come from 50 feet or less. That [takes a bear] 1.6 seconds," says Neal Wedum, retired Glacier National Park ranger. Be prepared to deploy bear spray by practicing pulling it from the holster and flipping off the safety (in an outdoor area) so it becomes an instant reaction. Carry the can in the same place on your belt or pack so you reach for it without thinking.

SPRAY IF CONTACT IS IMMINENT

Aim low, and spray even when the bear is beyond the can's range (about 30 feet) since they will run into the cloud. If that doesn't stop a grizzly, Kasworm says, "play dead." Curl up or lie flat on the ground, protecting your neck and other vulnerable areas.



Grizzly bear prints are shorter and wider than black bear prints.

In my case, I'd been lax on cleaning or locking up attractants, any odors that can attract a hungry bear. A grizzly's sense of smell is the stuff of legend. They are capable of locating a carcass under water, sniffing out crumbs dropped from your campsite lunch, and chances are, they even know what you had for breakfast as you hike down a trail. My biologist friend, Kate Kendall, a veteran bear researcher, told me that anecdotally, they've seen grizzlies sniff out a meal a half mile away.

After my late-night visit, I stopped composting and brought in the bird feeders. When I built a barn for my horses, the grain room was made to be secure from four-inch claws. If I've had unwelcome visitors since, R.D. and I must have slept through it.

Despite my changes, bears also don't forget a good meal. In 1988, a massive grain spill just outside Glacier National Park brought in bears for miles to feed on the rank, fermenting grain. Even after a cleanup, officials, wanting to be good neighbors (and avoid conflict), closed a nearby campground and prohibited stopping on a passing highway for years. Bears remember a food source and can return as long as they live.

But even after my grill-licking visitor, I was still foolish enough to not alter my daily habits. That is, until one day, when I returned home from a run on the trails behind my house and found Tim Manley, another Montana FWP bear specialist, in my driveway with his radio telemetry gear. He was locating a female with cubs near the woods where I just ran.

The realization was so obvious it hurt: While I'd adapted my home for the furry neighbors, I hadn't adapted myself. I didn't have to stop running or hiking, but I needed to look at the terrain differently, even on the prairie. This means avoiding dense, heavy cover areas, advice Madel echoed when we spoke. "Grizzly bears will develop these day beds and use them day after day. They're resting in that heavy cover."

I now make a point to give thick areas a wide berth, and keep my dogs close. I also make noise, whether it's talking, singing, or calling an occasional "Hey, bear!" if I travel through areas where I can't see what might be bedded down and recovering from an afternoon berry binge.

The same caution applies to recreating on the water. In Montana, an ideal Sunday stroll is along a riverbank with a fly rod in hand. Bears, however, feel roughly the same and tend to travel along river corridors and enjoy the cover of the heavy brush surrounding them.

Now as my family is planning a two-day float along the Marias River, the same one that flows through Shelby, we're adopting backcountry bear precautions. We'll hang our food at least 10 feet high and four feet away from the tree, and I purchased a bear canister just in case the branches are too high for me to toss the rope over a limb to hang my pack.



Glacier's Hidden Lake trails is frequented by grizzlies.

To be fair to the bears, it's not all fish carcasses and claw marks when they move back. Gardeners might appreciate that the bears are doing their part to control ground squirrel populations—if you plant it, those little marmot buggers will try to eat it. Of course, the bears aren't exactly precision excavators.

But grizzlies returning to their original ecosystem resonates on a primal level. Even after spending hundreds, if not thousands, of hours observing them over the years, I never tire of watching an animal that can overturn 300-pound boulders like pebbles and use its claws to deftly pull down chokecherry branches to reach the clusters of berries. And seeing the cubs sliding down snowbanks, or rambunctious sub-adult hooligans wrestling, is unmatched entertainment. It's also good to be reminded that we are not always the top of the food chain.

Yet somehow, these apex predators' survival rests squarely on our shoulders. Although grizzlies moving farther onto the prairie requires a new awareness, it's worth it. Like Lennemann's golfers, I am happy to adjust my behavior. After all, the bears were here first. PM

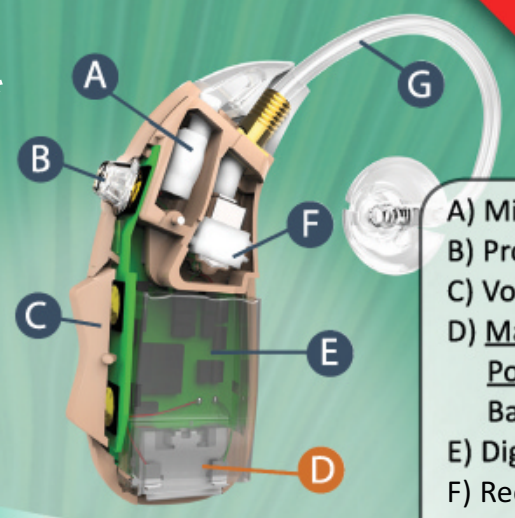
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PHOTOGRAPHY BY LAKOTA GAMBILL

For gearheads, half the fun of any adventure, whether it be a day on the water or a night spent sleeping under the stars, is turning to our closets and loading up our car (or pack, or bike, or boat). Although we regularly geek out about innovative materials and product design, it's not solely about the tech. The excitement also lies in what's ahead: making good, capable use of that gear to ensure we're better able to enjoy the activities we love (when shelter-in-place orders aren't in effect, of course). So during hundreds of hours of rigorous evaluation, we've camped through freezing temperatures and stormy nights, let headlamps run until they went dark to assess battery life, hiked more than double the length of California's John Muir Trail, measured how much boots' waterproofing leaked after holding them under water, and took temperature readings to gauge the insulation of coolers. It's all for the sake of finding the best shoes, sleeping bags, knives, packs, and other gear—assembled on these pages—for your next adventure.

HIKING PG.59 | CYCLING PG.62 | CAMPING PG.63 | GADGETS & TOOLS PG.66

HIKING

» Sturdy boots, comfortable packs, and one classy mug.



1

TREVOR RAAB (SOCKS)

1. BEST BACKPACKING PACK

Gregory Maven 65 *$250*

When it comes to fit, the Maven 65 and its men's equivalent, the Paragon 68, glommed onto our back immediately and stayed put. Gregory accomplishes this with its new FreeFloat Hybrid suspension system, which includes two mesh panels attached to the hip belt that allowed the pack to move with us exceptionally well, especially as we were hiking quickly. The back ventilation could be better, but we'll take a comfortable sweaty pack over an unwieldy one any day.



2

2. BEST HIKING SOCK

Farm to Feet Cascade Locks *$23*

We've tested more than 20 hiking socks in the past year and have yet to find one to dethrone the Cascade Locks. The three-quarter crew fits snugly, thanks to slight compression and the plaiting—the sock's soft merino wool sandwiches stretchy nylon yarns that grip and flex with your foot. Targeted padding on the top of the foot and under the heel adds a nice cushion.



3. BEST HIGH-TOP HIKING BOOT

La Sportiva Nucleo High GTX *$199*

The Nucleo High was ready for every obstacle we encountered: mossy rocks, loose gravel, and snow. Its Gore-Tex Surround waterproof lining kept us dry, the large rubber toe cap prevented stubbed digits, and grooves on the Vibram Nano sole improved traction. All that in a svelte, supportive boot that excels on backpacking missions and short hikes.

4. BEST VALUE HIKING BOOT

Timberland Mt. Maddsen Mid Waterproof *$115*

Comfortable from the first step, the Mt. Maddsen gives you day-hiking chops at a price well below what you would spend on many high-end boots. Hefty lugs and a TPU shank offered good grip and support on wet, rocky, and steep passes. We can overlook the weight (1 pound, 3.2 ounces, men's 12) given how well the EVA midsole cushioned our footfalls.

5. BEST MID-CUT HIKING BOOT

Danner Trail 2650 GTX Mid *$180*

When the going gets muddy, reach for the Trail 2650. The waterproof Gore-Tex membrane is complemented by perforations in the suede upper that made the boot more breathable than similar models. With Vibram's 460 sole, we didn't worry about slipping. Plus, a rubber bulge on the back—part of Danner's EXO Heel System—locked our foot in for blister-free hiking.





8

6. BEST JACKET

Arc'teryx Atom LT *$259*

With excellent temperature regulation and a lightweight design, this 14.6-ounce, slim-fitting jacket quickly proved its value during cold-weather expeditions and casual use. The 60-gram Coreloft synthetic insulation will keep you as warm in 30-degree weather as heavier coats, while the fleece-lined uninsulated side panels dump heat when temperatures creep up, or if you start to work up a sweat.

7. BEST DAY PACK

Deuter Speed Lite 24L *$105*

What we prize most in a day pack is comfort. Deuter delivered that by injecting plenty of support and cushion into the 1-pound, 11-ounce Speed Lite. The padded hip belt and U-shaped frame within the back panel kept most of the weight off our shoulders and on our hips to let our legs do the heavy lifting. Cushioning on the shoulder straps and a ventilated foam back panel kept the fully loaded pack from digging in.

7



8. BEST THERMOS

Purist Mover

$50 with Union lid

This 18-ounce bottle is handsome, simple to fill, and easy to drink from, especially when you upgrade to the Union straw lid. (And we highly recommend you do.) The Mover's interior is glass-lined, so we didn't get any metallic taste after filling and drinking from it a few times. Although other thermoses we've tested boast better thermal performance, this one kept water cool enough for our daily needs.

COURTESY HEATHER ANDERSON; COURTESY PURIST; COURTESY DEUTER

Go It Alone

Heather Anderson, who goes by the trail name Anish, set self-supported fastest known times on the Pacific Crest Trail in 2013 and Appalachian Trail in 2015. She shares what she loves about [and tips for] being alone outdoors.

Solo adventure in nature shows you a quieter space to dwell. Mindless entertainment is gone; it's just you. The initial shock of stepping into this private world can send people right back to their cars because they only have themselves for company.

These trips don't have to be epic. In fact, the less epic they are, the more likely you'll enjoy them. Start close to home. As you build your skill set and comfort level, you can branch out. Carry the essentials, and share detailed plans with someone, including your itinerary, trailhead location, campsites, and phone numbers of the appropriate land management agencies in case you don't arrive on schedule.



CYCLING

» A kit for urban streets and gravel trails, including a fast bike and high-vis smart lights.



9. BEST COMMUTER BIKE

Marin Presidio 1 *$680*

We loved zipping down streets on this thoughtfully equipped, aluminum-frame rig. The internal-gear hub and three-speed drive-train deliver fast and smooth shifting, while the hydraulic disc brakes offer dependable and impressive stopping power. Put the fender and rack mounts to use when you have a big haul, or swap out the puncture-resistant 700x32 tires for something a little fatter if you want to go explore gravel trails.

10. BEST BIKE LOCK

Altor Apex Ti *$189*

Clocking in at just over 1.5 pounds, the Apex Ti delivers an excellent weight-to-protection ratio. Altor built the body from a titanium aerospace alloy, with hardened steel rivet caps connecting the folding joints. The lock is long enough to secure your ride's front wheel and frame and comes with a bike mount.



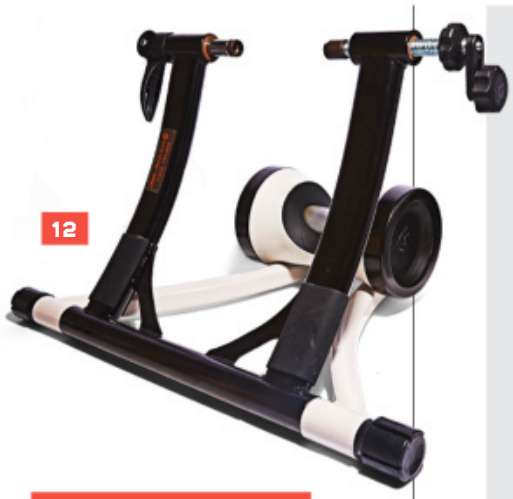
11. BEST COMMUTER PACK

Osprey Metron Commuter *$160*

Even fully loaded, the 26-liter Metron is comfortable to carry, thanks to its ventilated back panel, padded shoulder straps, and sternum and waist belts. We appreciated the dedicated shoe pocket and the fob on the front that we used to conveniently secure our helmet when we weren't riding. Should the skies open up, the rain cover (which stows in a bottom pocket) is there to keep your laptop and gear dry.







12. BEST BIKE TRAINER

Blackburn Fluid *$275*

The best-performing low-cost trainer we tested, Blackburn's Fluid accommodates wheels from 26x1 inches up to 29x2.3 (including all standard road sizes) without the need to adjust the roller tension. Just clamp your bike in with the flip of a quick-release lever and pedal faster for greater resistance. Plus, the lightweight frame folds up for compact storage.



13. BEST BIKE LIGHTS

See.Sense ACE Front and Rear Set *$98*

The ACE 250-lumen front and 125-lumen rear lights aren't your average smart lights. On-board sensors take 800 readings per second. When they detect something like an approaching car, the lights flash brighter and more frequently. See.Sense's app gave us the ability to select additional flash patterns and check the lights' battery levels from our phone. The app also sends theft and crash alerts.

TREVOR RAAB (BIKE); COURTESY SEE.SENSE (LIGHTS)



CAMPING

» Warm sleep systems, a premium camp stove, and this massive tent.

14. BEST FAMILY TENT

REI Co-op Kingdom 4

$429

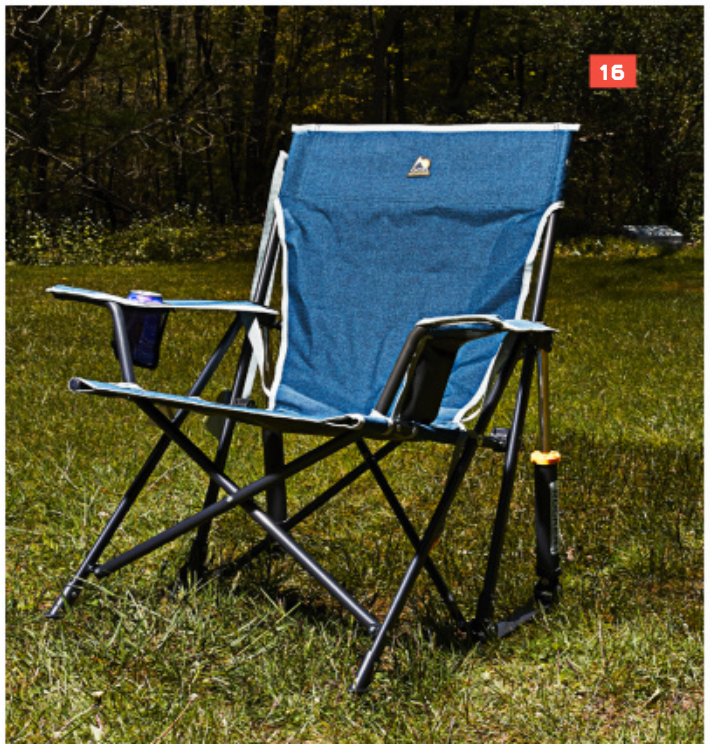
The Kingdom is one of the most spacious four-person tents you can find. Tall doors and vertical walls allow you to stand inside without crouching (in fact, reaching the ceiling in places proved to be challenging for our 5-foot-4 tester). And the nearly 70 square feet of floor space means you can spread out when you sleep or legitimately fit a party of four within the Kingdom. It's an 18-plus-pound beast, but gear storage abounds with 20 mesh pockets. And we can attest to the exceptional weather protection—the tent was still standing after a night of severe thunderstorms and high winds, during which only a nominal amount of water got in through the full-coverage rain fly.



15. BEST CAMP STOVE

Eureka Ignite Plus *$145*

Make a veritable campground feast with the Ignite Plus. The massive surface accommodates two 12-inch pans and sits flat, thanks to legs that screw in and out individually. Firing up with the press of a button, the propane stove is slower than some at boiling water but excels at low temps, nicely sautéing mushrooms in our comparison test.



16. BEST CAMP CHAIR

GCI Kickback Rocker *$50*

GCI has staked its claim as the king of camp comfort with its Rocker line of chairs. And the Kickback is the current standout, striking a good height balance for tall and short people. Pistons on the back legs provide an easy rocking motion but prevent the chair from folding down very small. That shouldn't be a problem, though, when you're taking it out for car camping, cheering from the sideline of your kids' game, or lounging in the backyard.

17. BEST SOFT COOLER

Yeti Hopper M30 *$300*

The cavernous Hopper M30 (it fit 12 cans and 11 pounds of ice with room to spare) is worth the significant cost if keeping things as cold as possible is your top priority. The magnet-and-buckle closure system and closed-cell foam insulation sealed in the chill. Afetr spending eight hours in the ice-filled soft cooler, cans emerged an average of 3.5 degrees colder than those from a competing model of the same size.



18. BEST AIR SLEEPING PAD

Big Agnes Q-Core SLX

$150

The Q-Core SLX lifted our tester a massive 4.3 inches off the ground—practically unheard of for an air pad. And the I-beam baffle construction provided stability and support that left him feeling well rested in the morning. Given that ample thickness, this pad is great for car camping, but it's still light and compact enough to take with you into the backcountry. Our 20-by-72-inch sample weighed less than 1.5 pounds. The synthetic Primaloft Silver within lends the Q-Core SLX very respectable insulation from the cold ground.

19. BEST VALUE SLEEPING BAG

Marmot Trestles Elite Eco 30 *$148*

Marmot avoids the major issue of most synthetic bags—bulk—in the Trestles Elite Eco series by blending three weights of recycled polyester fibers to create a compressible-yet-warm insulation. The Trestles packs as small as some down bags and won't falter when it gets wet like those might, which makes it a fine choice for backpacking. It can be a bit constrictive, but undoing the secondary zipper on the right side frees up some room at the chest on milder nights.

20. BEST SELF-INFLATING SLEEPING PAD

Therm-a-Rest Luxury-Map *$125*

Using pressure-mapping tech, Therm-a-Rest customized the layer of 3-inch-thick polyurethane foam, which is what makes the LuxuryMap as comfortable as it is. Since there isn't as much foam around the areas that support the head, shoulder blades, waist, calves, and heels, these bony and curvy parts of the body can sink deeper into the self-inflating pad. And for 2020, the company added its new TwinLock valve system, a set of one-way openings that made inflation and deflation even easier.

21. BEST THREE-SEASON SLEEPING BAG

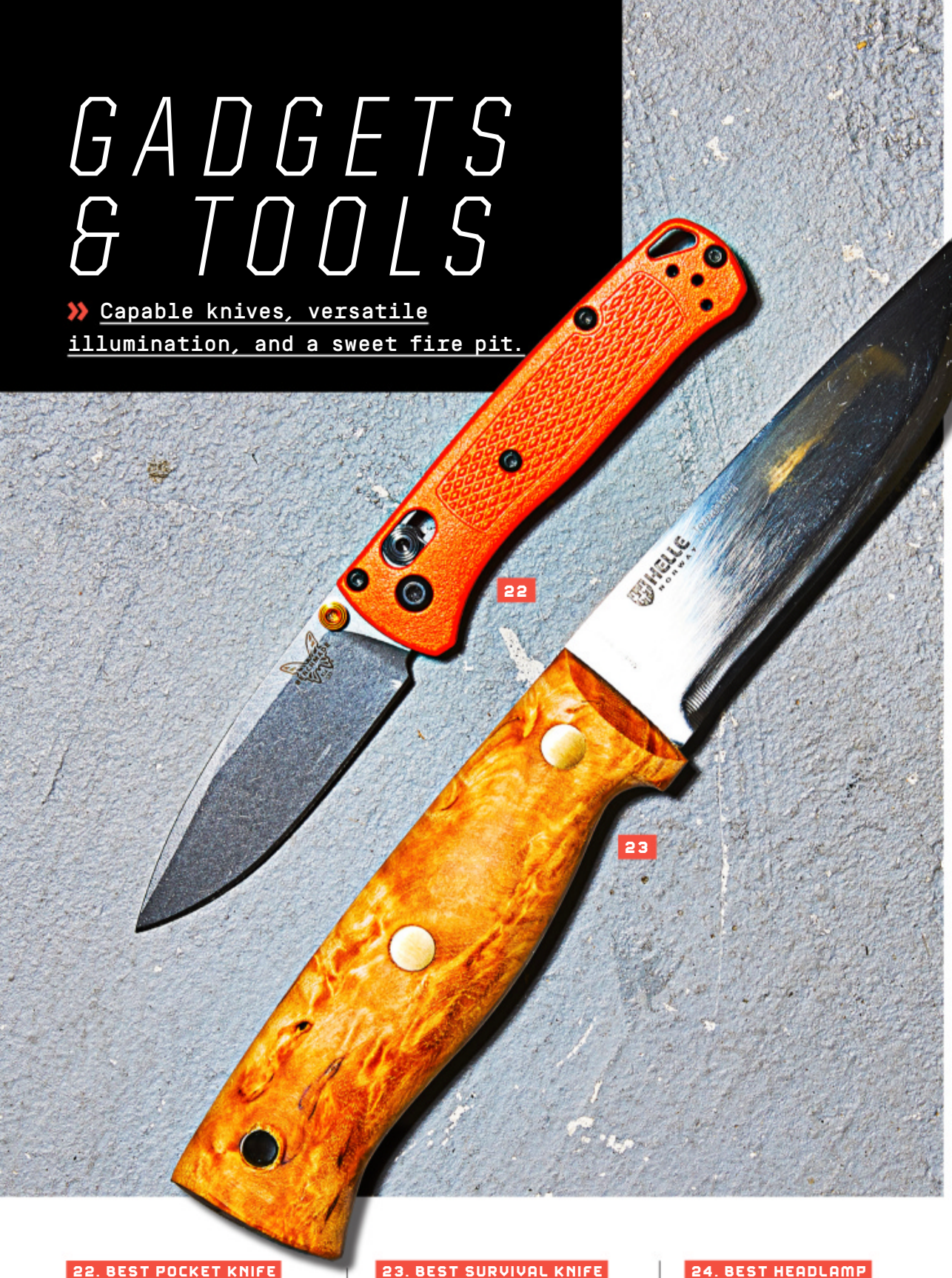
The North Face The One Bag *$289*

With two removable blankets, The One Bag delivers precise temperature regulation throughout the year. Zip just the lightweight synthetic outer layer to the base in summer, the 800-fill down midlayer (which doubles as a camp blanket) by itself in cooler temps, or both if you're braving alpine environments or winter weather. Zipping the layers to the base wasn't always smooth, and the midlayer's zipper had a tendency to snag on the draft tube. But a bag this versatile deserves a place in your camping quiver.



GADGETS & TOOLS

» Capable knives, versatile illumination, and a sweet fire pit.



22. BEST POCKET KNIFE

Benchmade 533 Mini Bugout *$140*

For a featherlight EDC that doesn't slouch on performance, pick the Mini Bugout. The 2.8-inch drop-point blade quickly and cleanly cut through food, cardboard, and thick rope in our testing, and the handle felt comfortable and secure even when we laid into it. Given the knife's 1.5-ounce build, we frequently forgot we had it in a pocket or holstered on our belt, making it a convenient option to carry everywhere.

23. BEST SURVIVAL KNIFE

Helle Temagami *$189*

There's no hiding the Temagami on your waistband. Good thing, then, that you won't want to—this knife is an absolute beaut, with performance chops to match. The 4.3-inch stainless-steel blade delivered quick, smooth cuts throughout our testing, and the handcrafted curly-birch handle felt comfortable in a variety of different positions. The three-quarter tang makes the 9.1-inch knife almost two ounces lighter than similar blades.

24. BEST HEADLAMP

Black Diamond Icon *$100*

Running on four AAs, the Icon is heavier than most competitors. But its long battery life and versatility proved indispensable. Turn the waterproof headlamp to its maximum 500-lumen output and easily cycle through the white, red, blue, and green colors, which make the Icon ideal for hunting, searching for roasting sticks after dark, or just reading before bed without disturbing any of your tentmates.





25. BEST CAMP LIGHT

BioLite BaseLantern XL *$130*

At 500 lumens, the BaseLantern XL is one of the most powerful camp lights we've tested—in a compact, sub-1.5-pound package, no less. Its functionality, though, puts it over the top. The BaseLantern doubles as a

power bank with two USB ports and connects to BioLite's app, where you can change the brightness and color, transform it into an alarm, and even program it to turn on or off when you leave your campsite.

26. BEST FIRE PIT

BioLite FirePit *$250*

We haven't tested a more feature-rich portable fire pit than BioLite's. Its removable battery pack powers a three-speed fan, which pumps air through 51 jets, helping quicken the burn and cut down on smoke. Plus, its USB output lets you charge devices—during our testing, it provided a full dose of juice to our dying infrared camera in a little over an hour. After the flames wind down, the inner grate and ash drain help with cleanup.





GETTY IMAGES (FIRE)

The Hidden Math of Fire-Building

Ask outdoorsmen and -women whether it's better to build a log cabin or teepee when starting a fire, and you're sure to get a range of vehement responses. But the secret to a roaring blaze isn't structure, it's numbers.

"Surface area is the key to a hotter fire," says Daniel Leavell, an assistant professor in Oregon State University's Department of Forest Engineering, Resources and Management. He explains it this way: If you had to choose between an 8-by-12-inch log and 32 quarter-inch sticks with an equivalent volume and moisture content, you will have a much easier time igniting the bundle of sticks. That's because the bundle's surface area is nearly 4.5 times greater than the single log's. That means you can spread out the sticks to create the necessary influx of oxygen to start and feed the fire.

Once your fire is built, surface area remains just as important of a factor. Many people make the mistake of only adding large logs once their fire is going strong. This results in a fire with less surface area to catch on, which burns cooler, and cooler fires are less efficient. The fuel they don't consume becomes smoke. Save your eyes from the harsh sting by feeding your fire with various sizes of logs.

// BY BRAD FORD //

The Best Smart Locks for Your Home or Rental Property



SMART LOCKS—OR SMART DEAD BOLTS, more accurately—allow you to lock and unlock doors remotely, check their status and history, and provide access to visitors when you aren't home. They employ Bluetooth, WiFi, or Z-Wave radio signals to communicate with apps on smartphones, WiFi bridges, or smart home hubs, and may also be integrated with security systems. If you want the convenience of smart locks but don't know where to start, we'll cover the basics to ensure you get one that's compatible with your home and helpful for your household.

HOW TO INSTALL

Smart locks generally come in two configurations for dead bolts. The first is the full dead-bolt lockset—including the dead bolt, the exterior keyed lock and/or keypad, and the interior thumb lever and plate. These will completely replace your existing dead bolt or can be added above a doorknob or handle. The latter configuration replaces only the interior thumb lever and plate, utilizing the existing dead bolt and exterior keyed lock. If you have a matching doorknob and dead bolt, or have all your locks keyed alike, then this option will let you keep your current setup. There are also full mortise-handle sets that include the handle and associated latch bolt, as well as the "smart" dead-bolt, all-in-one unit, but we focused only on the dead-bolt options.

If you're replacing an existing dead bolt or installing one in a predrilled door, the job is fairly easy and can be done with just one screwdriver in about 15 minutes. But if you're installing a dead bolt in a door that hasn't already had one, it'll take a bit more time and a door-hardware-installation jig to get it right. The kit will help get the holes positioned accurately and make the job go quicker.

HOW WE TESTED THESE SMART LOCKS

The locks on this list have been thoroughly vetted, evaluated, and tested by our editors. First, we installed each of them in a metal exterior door to assess fit and ease of installation. We then paired them with our smartphones, ran through the setup processes, and tested Bluetooth functionality. To connect the smart locks to a consumer-grade wireless network, we installed them all in a single test stand, took them off-site, and set up a live-stream video camera to monitor functionality. We then locked and unlocked them remotely using our smartphone, while reviewing the video stream, and confirmed lock status via the manufacturer's app. We were careful to test all of the smart locks' features, taking aesthetics into account.

TREVOR RAAB



SCHLAGE ENCODE SMART WIFI DEADBOLT $250

Schlage's Encode Smart Deadbolt offers similar features to other locks, but differs in its Grade 1 rating from the American National Standards Institute, the organization's highest for locks. Heavy metal housings enclose both the interior and exterior mechanisms. Installation requires only one screwdriver and 15 minutes. The Schlage Home app makes startup, management, and "smart" functionality a breeze. Schlage's Encode is ideal for people looking for robust physical security with the convenience of advanced smart-lock features.



AUGUST SMART LOCK PRO + CONNECT $280

August's Smart Lock Pro is a one-size-fits-all solution, allowing you to keep your existing dead bolt and keys. Installation and pairing it with your phone using August's free app was quick, painless, and intuitive. The model we tested also came with a Door Sense sensor, which allows you to check if the door is open or closed, and a Connect WiFi bridge to access lock function remotely. Without the WiFi bridge, the lock will function via Bluetooth only—which is still handy, since it can be set to automatically unlock when it recognizes when you get home.



KWIKSET HALO SMART LOCK $229

The Halo is a sturdy, complete dead bolt from Kwikset, a company that revolutionized residential locks with its tubular lock design more than 70 years ago. The lock's proprietary "SmartKey" technology allows users to re-key their locks with new physical keys in seconds, enabling them to manage the security of their physical keys in a quick, efficient manner.



NEST X YALE SMART LOCK $279

Yale built its reputation by making some of the strongest locks available for 180 years. Teaming up with Google's Nest brings it to the forefront of modern smart-lock technology by seamlessly integrating a high-quality dead bolt with a developed home automation platform that can connect with dozens of other Nest devices. The solid heft of this smart lock indicates the strength we expect from Yale. Since it has no key, the lock is pick-proof—you can unlock it only with the keypad or Nest app.



IGLOOHOME SMART DEADBOLT 2S $170

The Smart Deadbolt 2S may come from a lesser-known brand, but it's not a cheap imitation. Igloohome has made a nicely designed, well-built smart lock with some unique features. Its sleek touch pad with a hidden keyhole feels modern, and the five included keys have an unusual four-sided design. This lock isn't WiFi-enabled, so the app can't monitor or open it remotely—this can be done only within Bluetooth range. However, it will create access codes, from anywhere, that you can send to guests via text, email, or messaging apps, or even integrate with an Airbnb account.

11

Editors' Choice

// AWARD-WINNING TOOLS AND GEAR RIGOROUSLY VETTED BY OUR TEST TEAM //

▼ Nintendo Switch Lite Game Console

The Switch is one of the most fun, well-designed devices of the last decade, offering incredible versatility as a single- or multiplayer Game Boy or a dockable TV console. With the newer, cheaper Lite, we still played our favorite games but in a smaller, handheld-only package that's great when someone's hogging the big screen. It hasn't left our side in months. Consider us converts. **$200**

▶ Samsung Galaxy Note 10+ Phone

With its five cameras, the 6.8-inch Note 10+ delivered professional-quality pics whether we took advantage of the Pro setting—which let us manually tweak the ISO and shutter speed—or one of the 10 other more guided shooting modes. The user-friendliness extended to Samsung's Scene Optimizer, which automatically smoothed out details in our photos. We captured clear portraits and selfies, low-light images, and action shots and were able to edit in blur and other effects. **$1,100**

▶ Sony WH-1000XM3 Wireless Noise-Canceling Headphones

These comfy cans produced clear highs and deep, shuddering lows, with unmatched distinction between tones as we listened to songs, podcasts, and movies. Ambient mode was excellent at letting in outside sound when we needed it, and the noise-canceling tuned out most everything when we didn't. For sheer audio chops, this pair can't be beat. **$350**

POPULAR MECHANICS EDITORS' CHOICE

We put the latest tools, outdoor gear, and tech through the wringer every day in the Pop Mech Test Zone. Only the best of the best earn Editors' Choice. Every product here has been thoroughly evaluated by our team, and each offers exceptional performance, durability, value, or innovation—or a combination of all those traits. This is the stuff that makes every project or adventure easier and more enjoyable.

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The Original Handheld GPS Brought Us Everything From Safer Flights to Faster Door-Dash Deliveries

THANKS TO GPS-ENABLED PHONES AND watches, we take for granted that we can easily navigate into (and out of) any place or situation. But it wasn't until a foggy day in 1985 when an investor and electrical engineer named Ed Tuck piloted a twin-engine Beechcraft Baron across Northern California that the widespread potential of an emerging tech began to become clear: What if someone could harness the power of military global positioning satellites (GPS) to enable everyone to navigate the skies, waterways, and roads without aerial maps or radar signals, Tuck wondered.

Same now as when they were first launched in 1978, the GPS satellites flying 25,000 miles above the earth send a signal at light speed, and a receiver on the ground reports your relative position. In 1985, the U.S. had launched six satellites, which it used primarily to guide missiles. At that time, a few commercial navigation systems used them, but the receivers were the size of pizza ovens and cost at least $10,000. Tuck wanted something more portable—lighter, that ran off batteries, and crucially, affordable. His dream product cost only $300.

To fulfill that vision, Tuck and the engineers he recruited to form Magellan GPS would have to ▸

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12 This Changed Everything

▸ create, invent, or re-imagine nearly every component to develop what would become the world's first handheld GPS device. At the time, there weren't even any long-lasting lithium batteries to power these devices. Even the large commercial GPS units had to be wired to an AC power source. And there were no efficient LCD screens, either. So the device Tuck envisioned would need powerful processing chips that were also power-efficient.

The vital parts were too expensive to make the final product affordable, so Magellan developed their own, starting with the antenna. They found a company that could build one for $75, hundreds less than what was available at the time. Next, they began working with a high-performance chip maker using a new technology called monolithic microwave integrated circuit (MMIC). The chips could run for hours without overheating and in a wide-enough radio spectrum to capture satellite signals. With those parts, Tuck and his team now had their blueprint for a handheld receiver. By 1989, three years after the company's founding, Magellan launched its first device: the NAV 1000.

By the standards of today, it was giant—about the size of large walkie-talkie. But back then, it was magical. The 1.5-pound device was accurate to within 328 feet—enough to be useful. The first units were marketed to boaters, who usually worked from simple maps. Incredibly, Tuck and the engineers had been so successful at reducing power draw that the whole thing ran off of six AA batteries, which kept it going up to "a few hours."

At $3,000, the device cost 10 times as much as Tuck had hoped. Still, Magellan managed to sell about 500 units the first year. That relative success led to a boom in handheld GPS, creating an entire industry around the technology. Garmin launched shortly after. And by 1995, the United States had a fleet of 24 satellites sending signals down to countless handheld devices. With each new satellite, GPS devices became more reliable and accurate. When Garmin released its eTrex receiver in 2000, it was accurate to 50 to 65 feet. Now, just over 30 years since the NAV 1000 went on sale, devices can pinpoint your position within inches.

You might call it wish fulfillment for Tuck, who died in 2017. His vision was for a device that allowed anyone to find their location on the planet quickly and easily. The tech his company pioneered

5 HANDHELD GPS DEVICES THAT DO WHAT YOUR PHONE CAN'T

HIKING AND HUNTING
GARMIN ETREX TOUCH 35 $300
Good for geocaching, trekking, or hunting, the Bluetooth-capable Touch 35 features a 2.6-inch color touch screen, compass, altimeter, and 32GB memory card for storing maps offline.

BOATING AND FISHING
HUMMINBIRD HELIX 7 CHIRP MEGA SI GPS G3 $700
Land your catch and return to shore with this device, which has a 7-inch screen, over 10,000 lake and coastal maps, and lets you see 125 feet below or to the sides of your boat.

OFF-ROADING
MAGELLAN TRX7 $500
The TRX7 is shock-resistant and comes loaded with more than 160,000 high-resolution off-roading topo and base maps. Audible directions, real-time tracking, and off-course notifications help you find your way back to paved roads at the end of the day.

EMERGENCY COMMS
BIVYSTICK $349
In serious situations, grab the Bivystick. It pairs with your phone to send emergency texts and to track your location for hours—relying on satellites instead of cell tower, so you can use it anywhere. You buy credits and pay for only what you need.

CYCLING
WAHOO ELEMNT ROAM $380
A full-color screen lets you easily find and view routes. And high contrast between roads makes it easy to follow directions. Plus, you can navigate to a point on the map, which not all cycling GPS devices allow.









COURTESY GARMIN; COURTESY HUMMINBIRD; COURTEY MAGELLAN; COURTESY BIVYSTICK; COURTEY WAHOO

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Damascus steel is the stuff of ancient legend. Treasured by mighty warriors and made using a secret technique, Damascus steel was famed for its sharpness and durability, and was known to slice gun barrels in half and separate single strands of hair in two. The secretive, ancient forging technique mixed different steel alloys to form a supersteel, creating a rippled, wavy texture, which made Damascus steel instantly recognizable.

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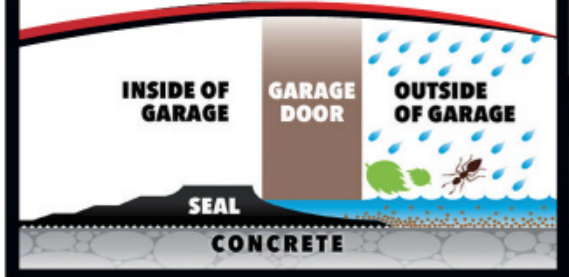
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// BY ROY BERENDSOHN //

The Best Portable ACs



THE PORTABLE AIR CONDI-tioner is essentially an AC on wheels. It's not a gimmicky contraption but an effective appliance, as millions of cool and comfortable people can attest. Unlike a heavy window AC with a single fixed location on a sill, the portable air conditioner can be pushed around in a room or moved between rooms, more accurately putting cold air right where you need it. For many people facing hot and sticky living conditions and an uncomfortable night's sleep, the appliance can be a tremendous problem solver.

For our test, we set the temperature on each air conditioner to 68 degrees, the fan speed to maximum, and aimed the appliance at a target eight feet away. Then we measured the temperature at four locations on the target. We also checked the appliance's outlet temperature (it should be consistent and a lot hotter than what the air conditioner is putting into the room). Next, we wheeled the appliances around on hard surfaces that amplify rattles and squeaks. To analyze the cooling value, we divided its cooling BTU by its cost. All that led us to these, the five best portable ACs you can buy right now. Trust one of them to help you survive these warm months.

EDITORS' CHOICE

LG LP1419IVSM

★★★★★

Price: $699 **Modes:** Cool, fan only, dehumidify **Cord length:** 54 in. **Hose length:** 57 in. **Amps:** 12 **BTUs:** 14,000

LG's LP1419IVSM was the most powerful we tested. We set the temperature and fan speed, and before we could even return to our notes, it was blowing ice-cold air. The automatic movement of the louvers ensured even temperature distribution at the target. It did almost as good of a job holding its temperature as the stalwart Honeywell below. Given that and the appliance's ample BTUs, this LG is well suited for large apartments or offices that might need exceptional cooling capacity. In terms of maintenance, the LP1419IVSM is very straightforward. Two grills cover its twin air filters, and neither of them requires tools for removal.

MOST ACCURATE

HONEYWELL HL09CESWK

★★★★★

Price: $380 **Modes:** Cool, fan only, dehumidify **Cord length:** 72 in. **Hose length:** 59 in. **Amps:** 8 **BTUs:** 9,000

This Honeywell is a robustly built and pleasant-sounding appliance. Its amperage and BTUs put it firmly in the middle range of power for portable air conditioners. It should more than hold its own in the average-size apartment. All of the air conditioners produced an accurate and stable temperature during our tests, but the HL09CESWK stood above them all, holding the target temperature within one degree. As far as maintenance goes, access to all the AC's air filters is very good: The top filter grill doesn't need a tool to crack open, while the lower grill is held with a single pan-head sheet-metal screw, not an exotic Euro fastener of some kind. If you lose that screw, a quick trip to the hardware store should be enough to find a replacement.



COURTESY LG; COURTESY HONEYWELL; COURTESY FRIGIDAIRE



HOW IT WORKS

An AC's plastic cabinet houses fans, a compressor-condenser, an evaporator, and a labyrinth of sealed tubing containing refrigerant—a material that cycles between being a liquid and a gas, absorbing and discharging heat as it does so. The refrigerant cools the tubing, and warm indoor air passing over it loses heat first to the cold tubing surface (that heat is ultimately absorbed by the refrigerant). As the air cools, moisture vapor in it condenses. The AC blows the cool, dry air into the room while ejecting the hot air outside via a discharge tube passing through one of the home's windows. The condensate (liquid water condensed out of the air) collects in a pan to evaporate or is used to cool the hot condenser.

MOST ENERGY EFFICIENT

LG LP0817WSR

★★★★½

Price: $319 **Modes:** Cool, fan only, dehumidify **Cord length:** 54 in. **Hose length:** 60 in. **Amps:** 9.2 **BTUs:** 8,000

What impressed us most about the LP0817WSR was its ability to quickly and quietly cool an area while drawing as little current as possible. That's no small benefit in any house, but particularly valuable in ones with creaky wiring or when other electronics are running on the same circuit. We liked the tool-free access to the washable air filter and the fact that the louvers shut tightly when the appliance is turned off (suppose your cat hops up onto it, spreading hair). We didn't have the opportunity to run this in true humidity, but we appreciate two aspects of how smartly the LP0817WSR handles condensate. First, it uses the gathered moisture to cool the condenser. This re-evaporates the liquid, reducing the amount you'll have to empty. Second, if the condensate pan fills up, this LG will shut off and its LED will display "E5," alerting you that you need to empty the pan.

BEST FOR KITCHEN COOLING

FRIGIDAIRE FHPC082AB1

★★★★☆

Price: $369 **Modes:** Cool, fan only, dehumidify, auto **Cord length:** 72 in. **Hose length:** 59 in. **Amps:** 9.5 **BTUs:** 8,000

Got a hot kitchen? The Frigidaire was the best of the bunch for this environment, with powerful cooling and a glossy exterior that's easy to clean, thanks to its relatively few seams to trap dirt and grease. Another kitchen-friendly feature is the tool-free access to its air filter—simply unsnap the top air-intake cover and slide out the washable filter. And the lower air-intake cover is attached with a single Phillips-head screw. Remove that, unsnap the cover, and vacuum the lower area of the appliance as needed. Generally speaking, all portable air conditioners are easy to move. But this Frigidaire is particularly maneuverable, with



a slightly lower center of gravity and two recessed side handles. We could see that feature as being a help in a kitchen (or anywhere, really) when it comes time to mop or vacuum the floor; scoot the FHPC082AB1 out of the way, clean the floor, and move it back. Its air distribution is also very good both in the regular mode (fixed direction) and the swing setting, which cycles the louvers back and forth to spread the cool.

FASTEST COOLING

HONEYWELL MN12CEDBB

★★★★½

Price: $609 **Modes:** Cool, fan only, dehumidify **Cord length:** 72 in. **Hose length:** 47 in. **Amps:** 9.5 **BTUs:** 12,000

The MN12CEDBB is a powerful, fast-working appliance. It's a good fit for rooms that are particularly stuffy, also homes in dusty urban areas or rural ones with lots of trees and, thus, pollen. We say this because it was the only AC with a large, slide-out air filter—there's no grill to remove. This feature promotes easy and frequent cleaning of the filter, keeping your indoor air cleaner in the process. This Honeywell is also a fairly substantial appliance. Case in point, it has two hoses: one that brings outdoor air in so the AC can cool, filter, and dehumidify it; the other through which any leftover stale, humid air is discharged back outside. In theory, this system should prevent the AC from drawing a negative pressure and pulling any pollutants from the outdoors into the house.



14

How to Be Good at What You Do

THOMAS BERNICH, 48, OWNER OF BROOKLYNPHONO, BROOKLYN, NEW YORK

Watch the complete **MADE HERE** video series on YouTube.

MADE HERE

WHEN I VISITED A vinyl plant in Queens in 1998, the product consumed my life. Something about seeing the process up close and holding a record captured my soul.

I didn't have a career at the time, making money working for electrical and mechanical contractors. I solicited money from family and acquired the equipment needed to make vinyl, including two over-100-ton hydraulic presses. Their condition wasn't great, but they allowed me to get started.

That first batch took a tremendous amount of energy. The system crashed after making two records. It was, of course, disheartening, but I knew it wouldn't be easy. Everything I'd read indicated that it was like jumping through hoops on fire that got higher and smaller as you went. Once you get through them, though, the feeling is beautiful.

I may not be the artist, but I do feel connected to the art through what I do. You are creating the vessel for an artist to generate their idea. When it goes out into the world and people enjoy it, nothing could be more rewarding.



HOW IT'S DONE

"Sound engineers produce the lacquer or copper discs that are electroplated to make nickel copies that will act as top and bottom molds. Those discs—or stampers—go into our presses. We sandwich extruded polyvinyl chloride, co-polymer preforms in between them, and heat and compress them. Finally, we cure the finished product and trim the excess material.

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